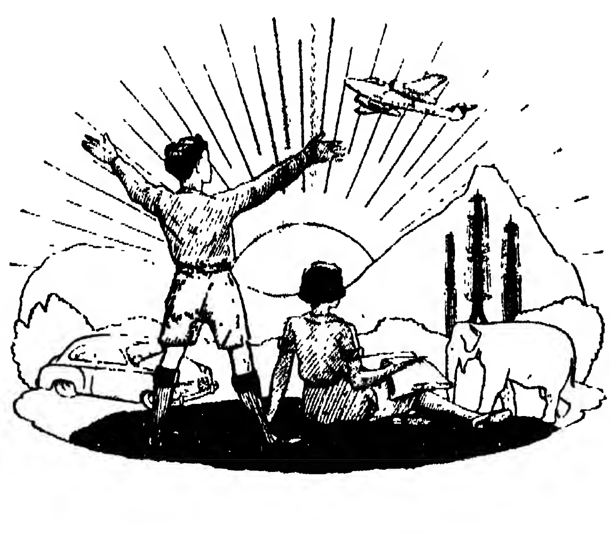
THE

WORLD OF WONDER

10,000 THINGS
Every Child Should Know

Edited by
CHARLES RAY



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HOW A SPEAKING-TUBE CARRIES SOUNDS

Everyone who has used a speaking-tube knows how easily a conversation can be carried on between two distant parts of a building. But exactly why a tube should assist conversation in the way it does is not so well known. On this page we see by means of picture and description the reason the voice carries farther through a tube

In many houses and offices and institutions like hospitals, as well as on board ship, the speaking-tube is a familiar object. It consists of a cylin-

Talking into a speaking-tube at one end of a building

drical metal tube which runs from room to room, and in the rooms has an extension of flexible india-rubber tubing with a bone mouthpiece, which can also be used as an ear tube. In this mouthpiece a whistle is generally inserted, so that the person at the other end of the tube when he wants to speak can give a signal by blowing through the tube and sounding the whistle.

The speaking-tube is a very efficient instrument, but in these days it is not used as much as it once was, because it has been to a large extent superseded by the telephone. Thin wires can be carried to any part of a building so much more conveniently and easily than a tube with a diameter of nearly an inch. The wire can twist and turn at all angles without disadvantage.

We have already seen on page 868 how the waves set up in the air by a sound spread out and become dissipated the farther they travel. By using a tube to carry the waves we do two things. In the first place we prevent the sound waves from spreading out and being lost in space ; and in the second place we emphasise the sound, because in the tube the waves are reflected from side to side again and again, and their strength or energy is thus maintained for a very great distance.

Scientists have formulated a law about the transmission of sound which says that the intensity of sound decreases inversely as the square of the distance. We may put this in more simple language, thus: if sound has a certain intensity after travelling a certain distance, then when it has travelled twice the distance it is not half as loud, but a quarter, or in other words a sound, to travel twice as far, must be made four times as powerful.

This shows what happens inside the speaking-tube. The waves of air are reflected from side to side of the tube, and are thus carried with very little reduction of energy to the listener waiting at the other end of the tube

This law, however, does not apply to the case of sounds carried inside tubes, especially if they are straight and cylindrical in form. The picture-diagram on this page makes it clear why this is. We can see how the sound waves are reflected again and again so that they carry for a very long distance through the tube.

Early in the last century a French scientist named Jean Biot carried out many experiments in transmitting sound through tubes. He found that when he spoke through one of the Paris water pipes, which was 1,040 yards long, his voice lost so little of its intensity that a conversation could be kept up quite easily between the two ends of the tube when the talkers spoke in a very low tone.

Where the tube is of large diameter the sounds become weakened much more rapidly, and this is also the case if the inside of the tube is rough instead of being smooth. The dissipation of the sound waves is very much like the dissipation of light when it strikes a rough surface.

Biot, however, proved that if a tube of the right kind were laid down between two towns fifty miles apart, a conversation could be carried on between the towns which would be quite audible at either end.

The speed of sound is about 1,118 feet per second, so that the sounds would travel the fifty miles in about four minutes.

England was the first country to use speaking-tubes for practical purposes in buildings, and they were certainly invaluable before the days when the telephone came into general use.

Listening by means of a speaking-tube to words which are being spoken at the other end of a building

THE TRUE STORY OF A GHOST'S PRANKS

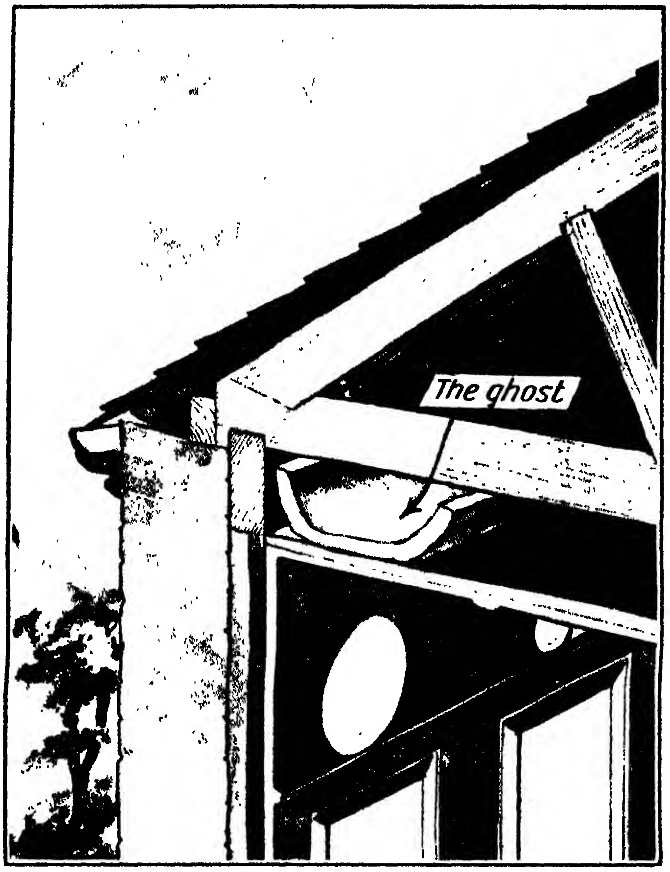
One kind of energy can be transformed into another kind. We know that when rub a knife backward and forward on a stone, to sharpen it, the blade gets hot. The to and fro movement of the blade on the stone has been transformed into heat, or, to put it more scientifically, energy of movement has been converted into energy of heat

The same thing happens if we strike a flint again and again with a hammer. Not only does the hammer become warm, but we hear the sound of the blow and see sparks fly from the flint Here the energy of movement is converted into three kinds of energy – those of heat, light and sound

Noises in the Dusk

Some years ago, the people who lived in an old mansion in the country used to hear strange noises on summer evenings. After the sun had gone down, there used to be a loud clatter, as though feet were passing between the ceiling and the roof of a gallery For many years the mystery remained unexplained, and the sounds were attributed by superstitious people to a ghost, who was said to walk the gallery at dusk

But one day, when the roof was being repaired, it was found that between the gallery ceiling and the roof there was a long leaden gutter, fixed in such a position that when the hot summer sun poured on the roof and the gutter became warm, it could only expand by rising from its bed. Then, in the cool of the evening, when the gutter lost its heat, it contracted and fell back with a clatter.



The home of a ghost that caused a good deal of fear

It was the sound thus caused which echoed in the gallery and gave the impression of a ghost walking. No doubt hundreds of other cases of supposed supernatural occurrences could be explained thus.

At another old house in the country, after everyone had gone to bed at night, the sound of footsteps could be distinctly heard coming up the staircase. Night after night, a watch was kept, and although the sounds could be heard by all, not a sign of anyone could be seen.

Laying the Ghost

It was all very weird and disquieting. If ever there was a case of a ghost moving about an old house, here was one.

Then a man who thoroughly understood old buildings gave the true explanation, and very simple it was. The timber work of the staircase, being very old, was pressed down when people travelled up and down during the daytime, but at night, when all was quiet, it gradually sprang back to its old position, and this, as it occurred on stair after stair, gave the impression of footsteps

HOW TO MAKE & USE A SIMPLE BULL-ROARER

We have already seen on page 1004 how to make a boomerang, that ingenious form of missile which is used by the Australian aborigines, and which when sent spinning returns to the place where its thrower stands

Here is another clever device of the Australian natives, or "blacks," as they are called It is known as a bull-roarer and is quite easy to make

We get a piece of wood an inch or two wide and several inches long Then at one end we bore a hole sufficient to take a piece of strong but thin string or cord. Linen tape is very suitable. We thread the string or tape through the hole and fasten it securely Then holding the other end of the string in our hand and giving it, perhaps, a twist round our finger or hand for security, we whirl the piece of wood round and round as rapidly as we can. The string should be about three feet long.

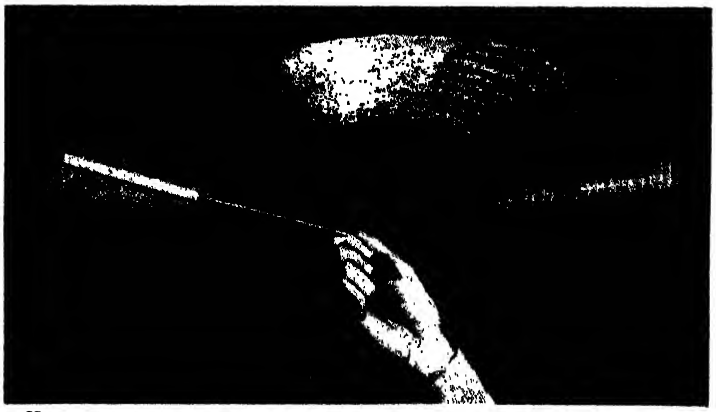
As the bull-roarer is whirled round and round it rotates rapidly on the end of the string, twisting the cord till it will twist no more Then, still whirling, the string untwists, the bull-roarer rotating in the opposite direction on the end of the string.

As it spins round in its course the rotating wood sets up vibrations in the air which we hear as a series of groans or booings, one at each twist of the string

In Australia the native men use the bull-roarer to frighten their women and children, telling them that the sound is the voice of an angry spirit.

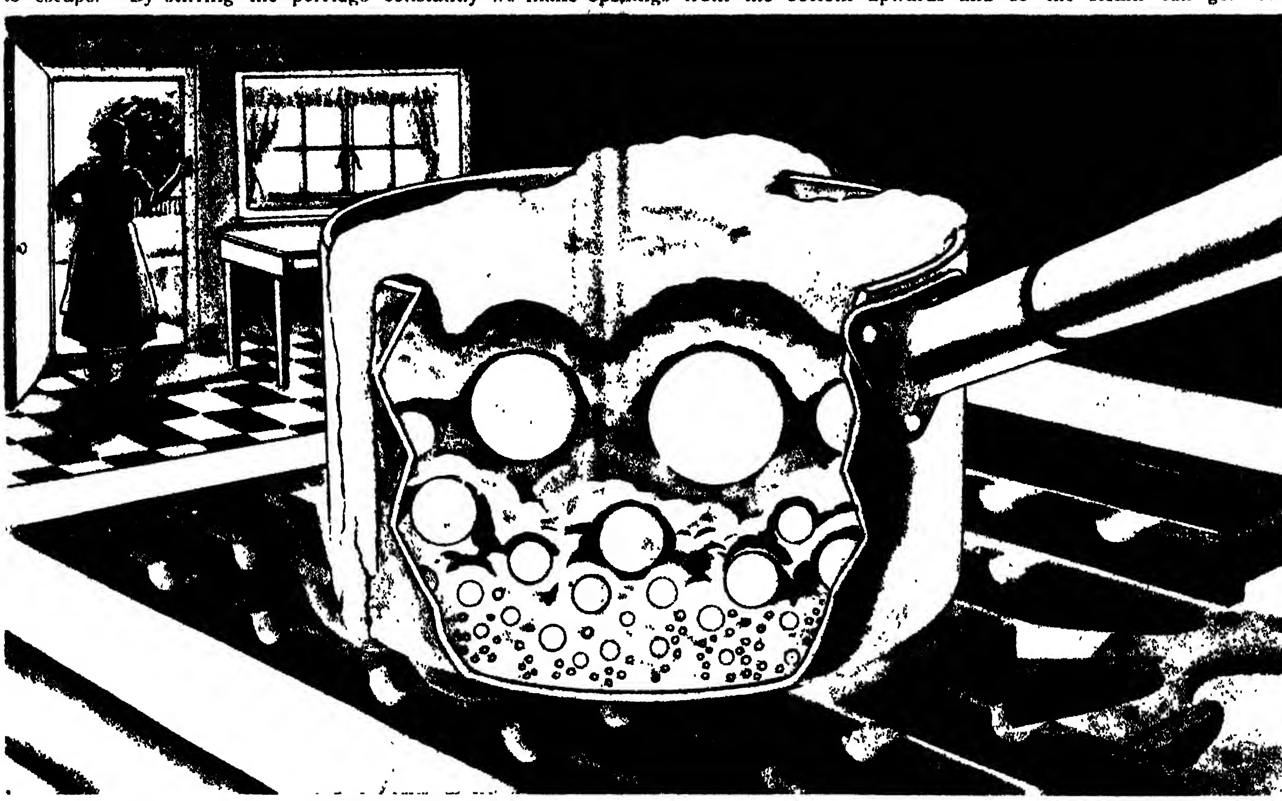
It is interesting to remember that the rustling of the trees which we hear when the wind is blowing is due to the leaves as they flutter rubbing against one another. A leaf on its stem cannot whirl round and round like a bull-roarer, but when the wind blows upon the leaf it twists the stalk as far as it possibly can and then turns the other way, untwisting the stalk.

The leaves of the poplar trees rustle more than those of other trees, and this, according to Sir William Bragg, the distinguished scientist, is because the stem of the poplar leaf is in section more like a piece of tape than a round piece of string, and so it twists more easily under the wind.


How a home-made bull-roarer is whirled round and round on a string

WHY THE PORRIDGE IN THE SAUCEPAN BOILS OVER

When porridge is made in a saucepan it must be stirred continuously as the meal is dropped in or it will boil up and over the edge of the saucepan. Why does the stirring stop this boiling over? Well, the pictures on this page explain the matter. As more meal is put in, the porridge becomes more and more viscous or gluey and the steam that is formed in the lower part finds it difficult to escape. By stirring the porridge constantly we make openings from the bottom upwards and so the steam can get out



If the porridge is not stirred it boils up and pours over the side of the saucepan, as shown in this picture. The reason for this is that owing to the viscous nature of the thick porridge the bubbles of steam forming in the lower part cannot escape through the porridge into the air. They therefore go on expanding in the porridge till at last they become so big and the power of the steam so great that they lift up the porridge, and this happening in many places we see the surface rise and flow over the edge

A LENS LIKE AN INSECT'S COMPOUND EYE

Here is a girl's portrait as seen by means of a new lens which has been produced to give dream effects in moving pictures. The lens has many six-sided facets each recording only a small part of the face. It is made on the principle of an insect's compound eye, which has sometimes 27,000 hexagonal facets. It is believed that each facet of such an eye perceives only a small part of the field of vision, the insect's view being made up of a vast number of small pictures like a mosaic, but pieced together better than the face in this lens. In some water insects the facets are few in number and large in size and, further, instead of being hexagonal they are circular

HOW A JET AEROPLANE LOOPS THE LOOP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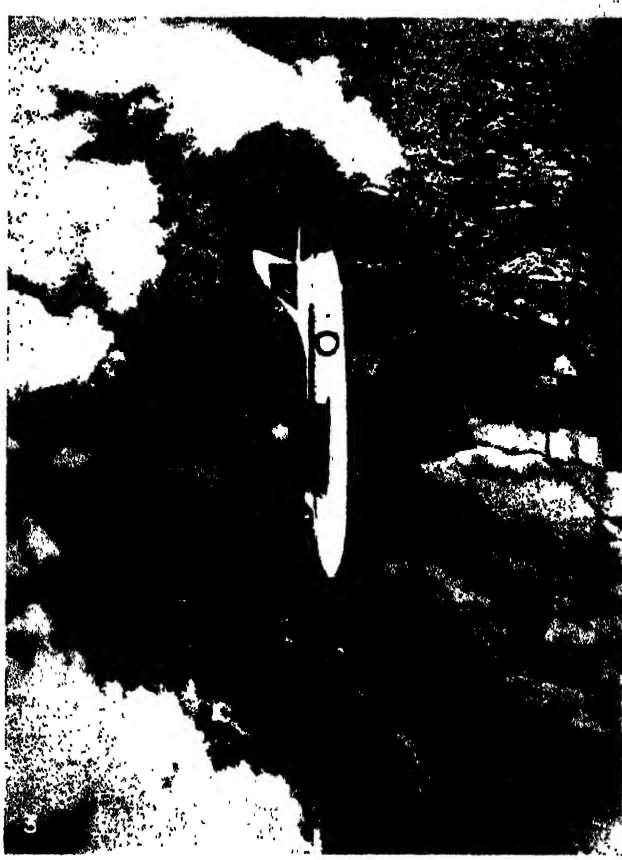
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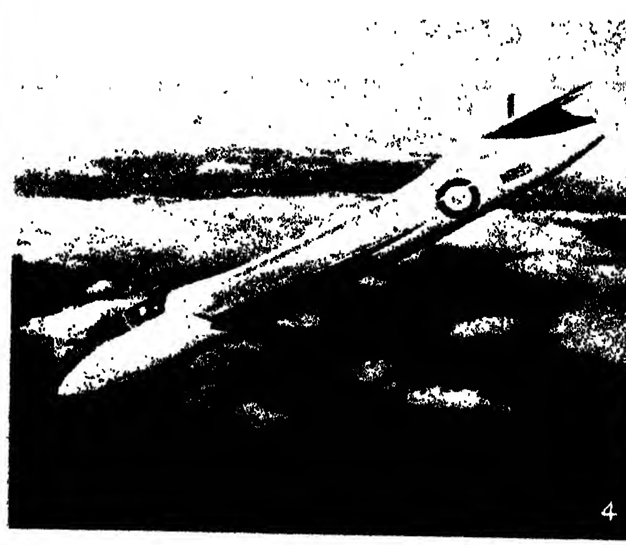
These photographs of a jet-propelled Hawker Hunter looping the loop were taken from another jet aircraft, a Meteor, which looped the loop with it. In the first picture, the Hawker Hunter is climbing straight upwards to a height of 12,000 feet at a speed of 460 miles an hour. Having turned upside down at the top of the loop, the aeroplane curves down (2) to complete a great circle, and in the third photograph dives nose first towards the earth. In the fourth photograph the Hawker Hunter has begun to level out to fly in a straight line. Built for the Royal Air Force as an intercepter fighter, the Hawker Hunter went into squadron service in 1952. It has swept-back wings and has travelled faster than the speed of sound, about 760 miles an hour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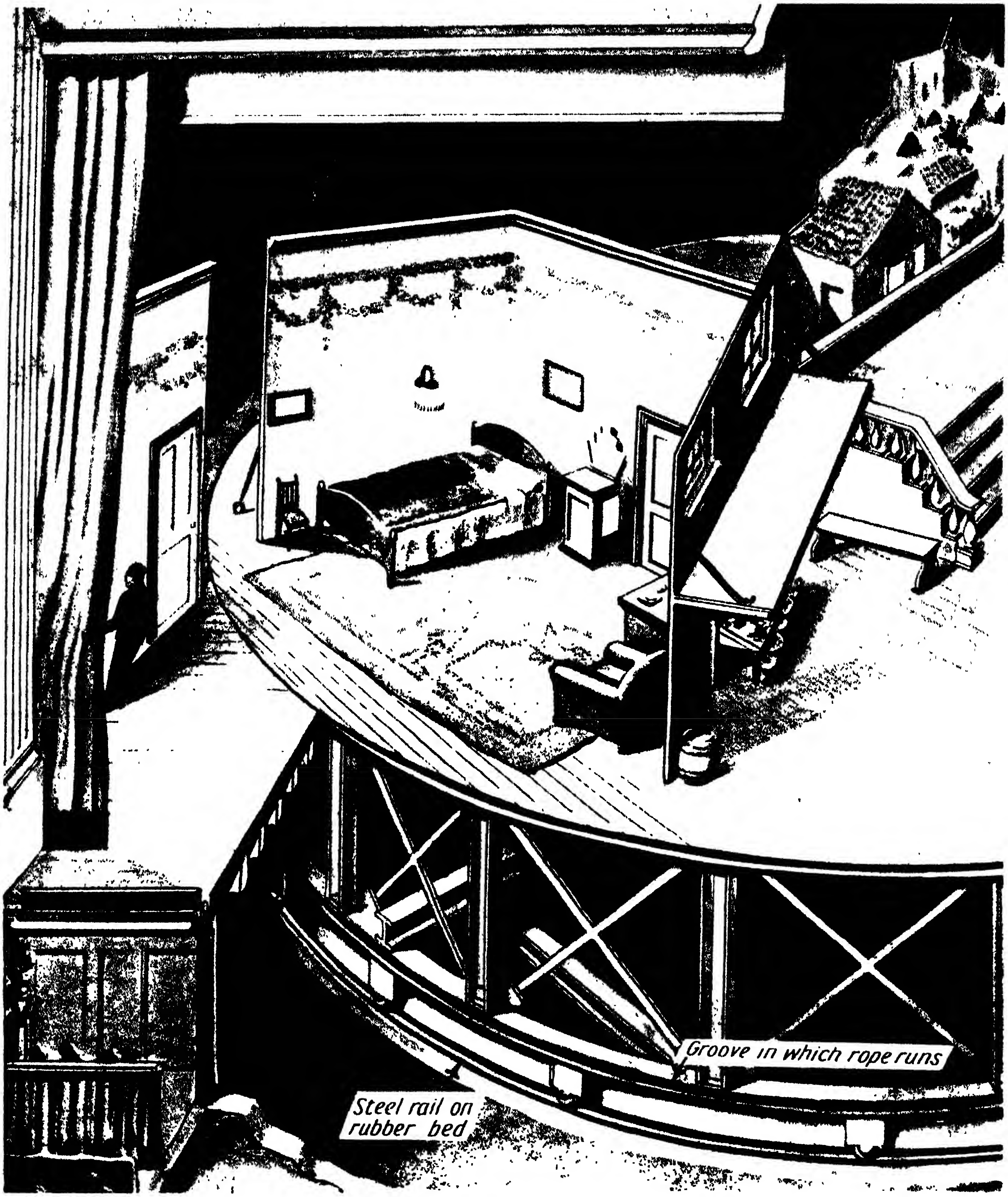
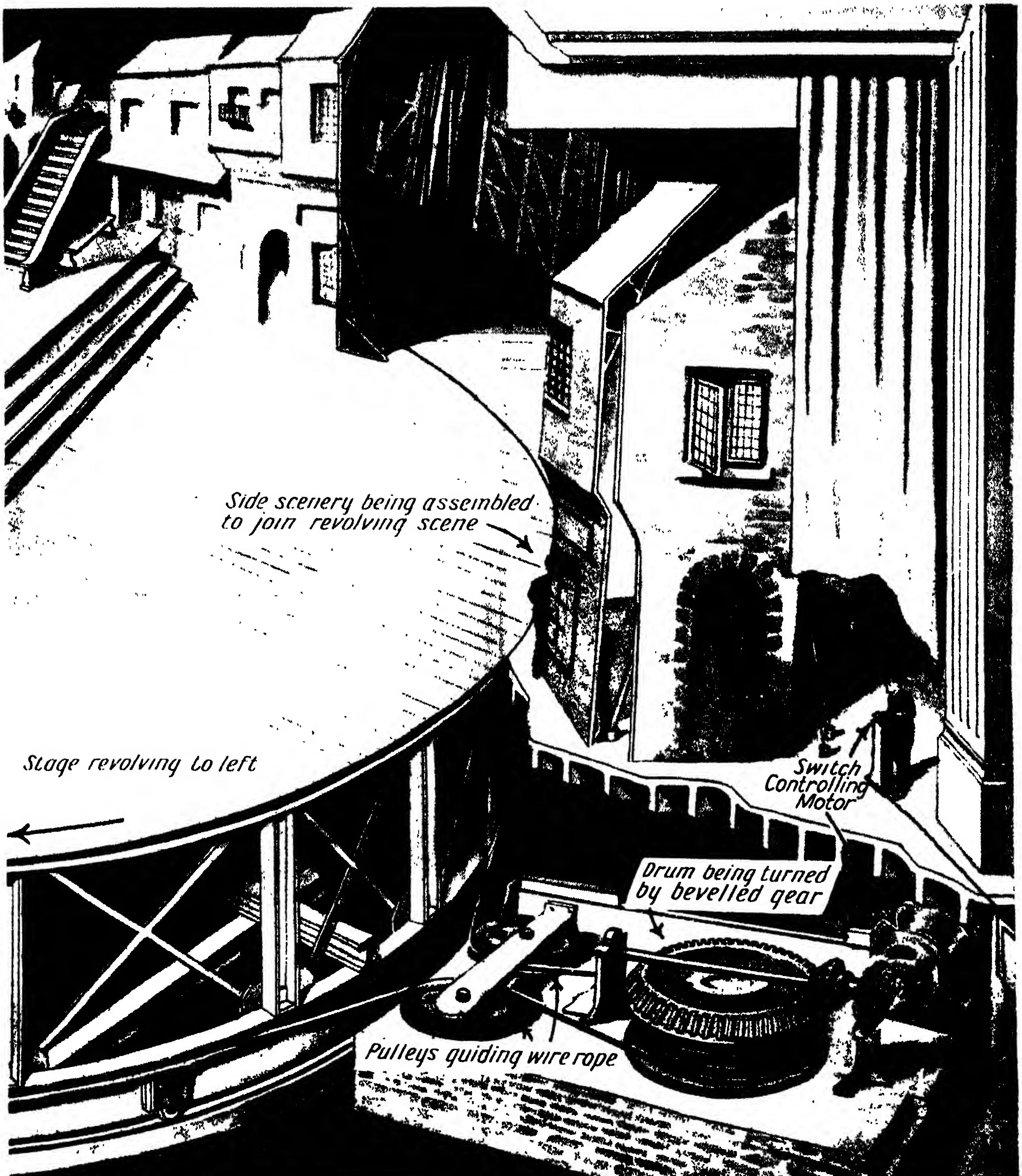
HOW THE REVOLVING STAGE AT A BIG



The theatre, in order to compete successfully with the cinema, has had to make itself very up to date and in recent years it has been adopting all kinds of mechanical devices to help the presentation of the show. At one or two big theatres a revolving stage has been introduced in order that there may be no delay between the scenes. While one scene is exposed to the audience the next scene is being got ready on another part of the stage, and in a few moments the stage can be turned round so that the new scene is before the audience while the previous one has passed out of view. The stage takes so little time to revolve that if the whole theatre is put into momentary darkness the scene can be changed before the lights are switched on again. It is a marvellous device, and in this picture the artist shows how the revolving stage at a large London theatre is worked. He has cut away the front part of the stage, which is fixed, in order to show the method of revolving. The stage, which is built on a framework, has a number of wheels which run on a circular steel rail resting on rubber. Under the stage manager's direction a mechanic pulls a switch connected with a

THEATRE CAN BE MOVED BY ONE MAN

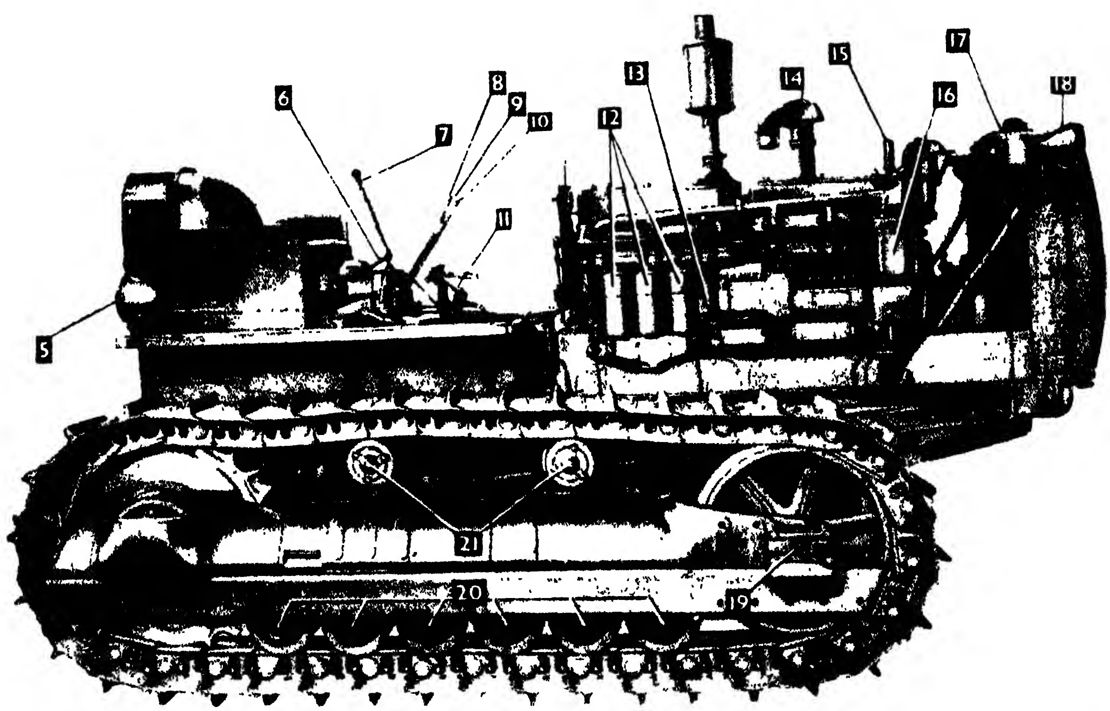


motor, so setting the machinery in motion. By means of a worm-wheel connected with a toothed wheel, bevelled gears are set revolving and a wire rope which moves in a groove beneath the stage is pulled round, revolving the stage with it. When the new scene has come round side pieces are connected up with it in an instant, and the actors are quickly in their places ready to carry on the play. A full stage of scenery is, by this device, replaced by an entirely different set within thirty seconds. In the picture is shown, on the left, a bedroom scene being turned away while an outdoor scene is being brought into view. Far more scenes can be presented thus, in a given time, than were ever possible before. How the actors of old times, and the theatre-goers too, would be surprised if they could return and see the clever and ingenious mechanical devices that are now used in connection with the stage to expedite the changes and assist the illusion! In Shakespeare's time period costumes were seldom worn, scenery was rare and the place where the story was supposed to be laid was often indicated by placards, while the stage lighting was provided by rows of candles.

VEHICLE THAT CARRIES AND LAYS ITS OWN

The parts of the caterpillar tractor shown numbered on the left are: 1, steering clutch control and shaft; 2, transmission gear box; 3, sliding collar of flywheel clutch; 4, flywheel clutch driving plate. A caterpillar tractor is steered to the right by stopping the right-hand track and accelerating the left-hand track; to steer to the left, the left-hand track is stopped and the right-hand track accelerated.

Below is a photograph of the right hand side of a caterpillar tractor showing: 5, rear lamp; 6, throttle control lever; 7, gear shift lever; 8, flywheel clutch-control lever; 9, left steering clutch control; 10, right steering clutch control; 11, steering-clutch brake pedal; 12, diesel engine oil filter; 13, diesel engine breather; 14, diesel engine exhaust; 15, starting engine exhaust; 16, diesel engine fuel filter; 17, radiator for cooling system; 18, front lamp

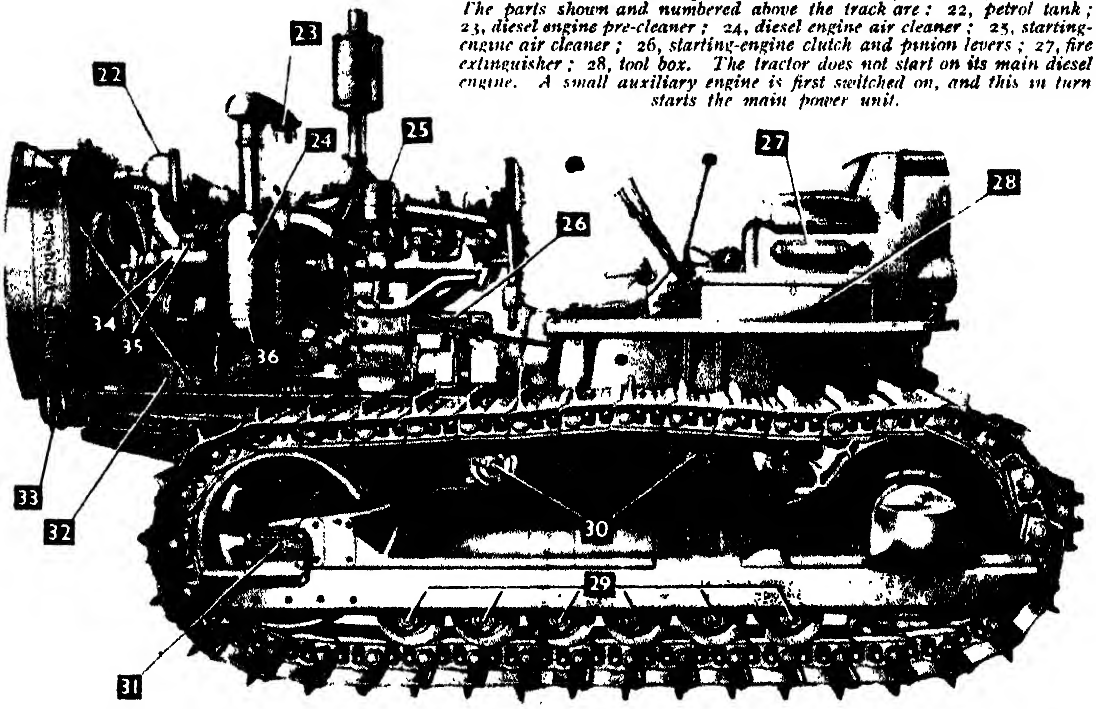


The components numbered on the lower part of the right-hand side of the caterpillar tractor are: 19, right-side front idler; 20, right-side track rollers; 21, right-side track-carrier rollers. The diesel engine drives on to the rear axle which carries a sprocket (cogged) wheel on each end. The jointed caterpillar-track has on its under surface ridges which fit over the sprocket wheels, and as these turn they pull the track over the front idlers and so move the tractor forward. The track is supported between sprockets and idlers by the two sets of rollers (20 and 21).

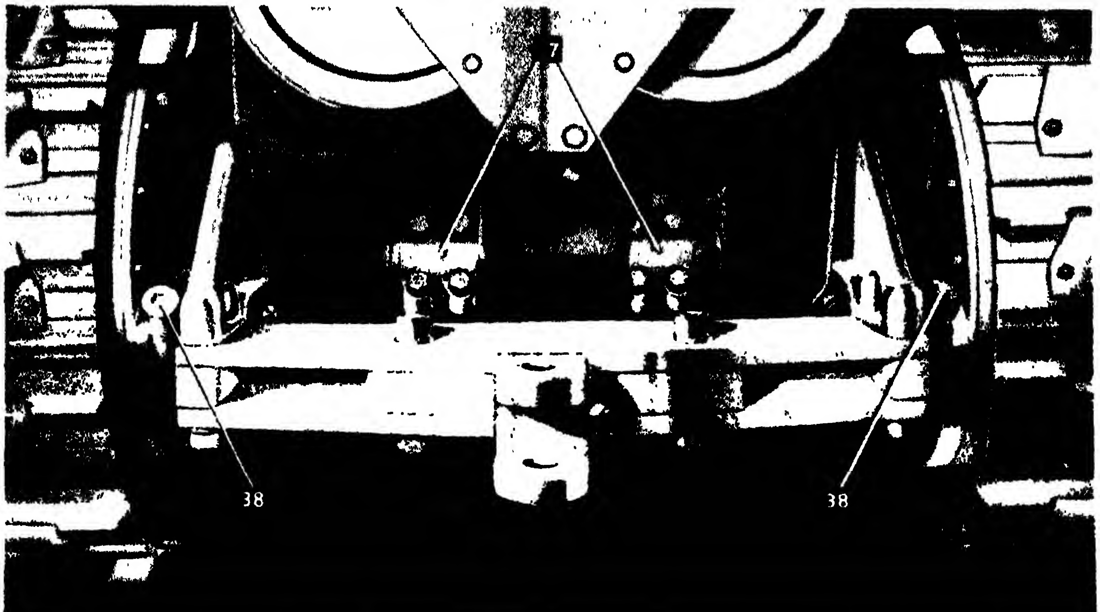
The principle of the caterpillar track for moving a vehicle across soft or rugged ground is such a simple idea that it is surprising no one thought of it earlier than 1907. But for centuries men and horses had struggled to pull wheeled carts across rough ground, and often only succeeded in bogging their vehicles down. The caterpillar vehicle is, in effect, a vehicle that carries its own road and lays it down as it moves forwards or backwards. It could quite easily have been used for horse-drawn carts. Caterpillar tracks consist of two bands or belts made up of jointed steel plates and passed round two pairs of wheels placed some distance apart. The rear pair of wheels are driven by an engine and as they revolve pull the endless tracks round with them In this way, the vehicle travels on the inner surfaces of the tracks which are constantly rolling round the wheels

ROAD OVER THE MOST RUGGED OF GROUND

Here you see what the caterpillar tractor looks like from the left-hand side. The parts shown and numbered above the track are: 22, petrol tank; 23, diesel engine pre-cleaner; 24, diesel engine air cleaner; 25, starting-engine air cleaner; 26, starting-engine clutch and pinion levers; 27, fire extinguisher; 28, tool box. The tractor does not start on its main diesel engine. A small auxiliary engine is first switched on, and this in turn starts the main power unit.



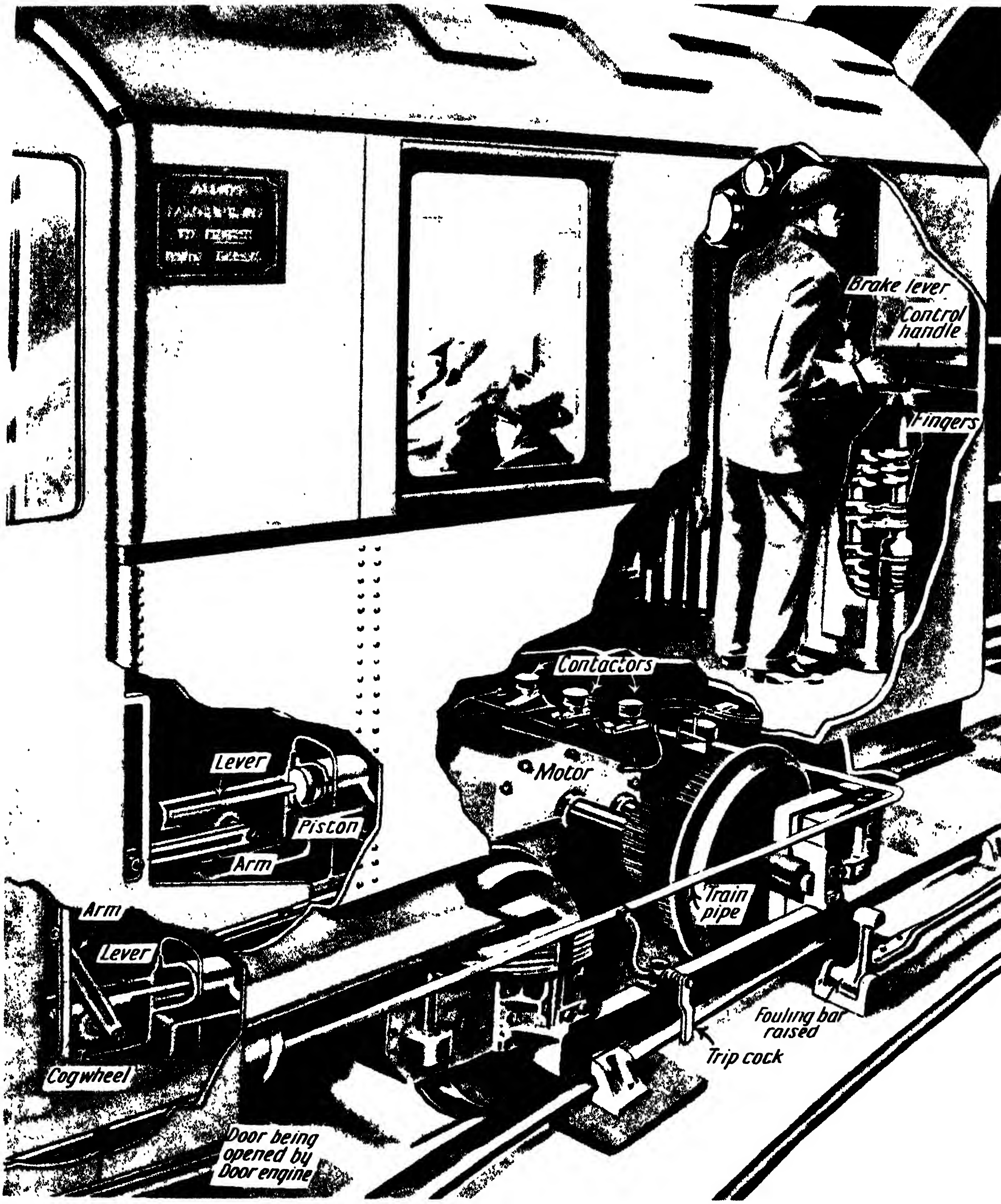
The parts numbered below the track are: 29, left-side track rollers; 30, left-side track-carrier rollers; 31, left side front idler; 32, front support bearing; 33, plug closing the drain pipe for the cooling system; 34, dynamo for supplying current to the electric starter; 35, switch for turning on or off front and rear lights; 36 diesel engine oil cup.



The photograph above of the rear of the caterpillar tractor shows: 37, the under-bearings of the frame on which are mounted the track rollers; 38, points through which oil is pumped to lubricate the sprockets driving the caterpillar track. On the rear is mounted the towing bar and shackle to which is hitched the vehicle or implement towed by the tractor.

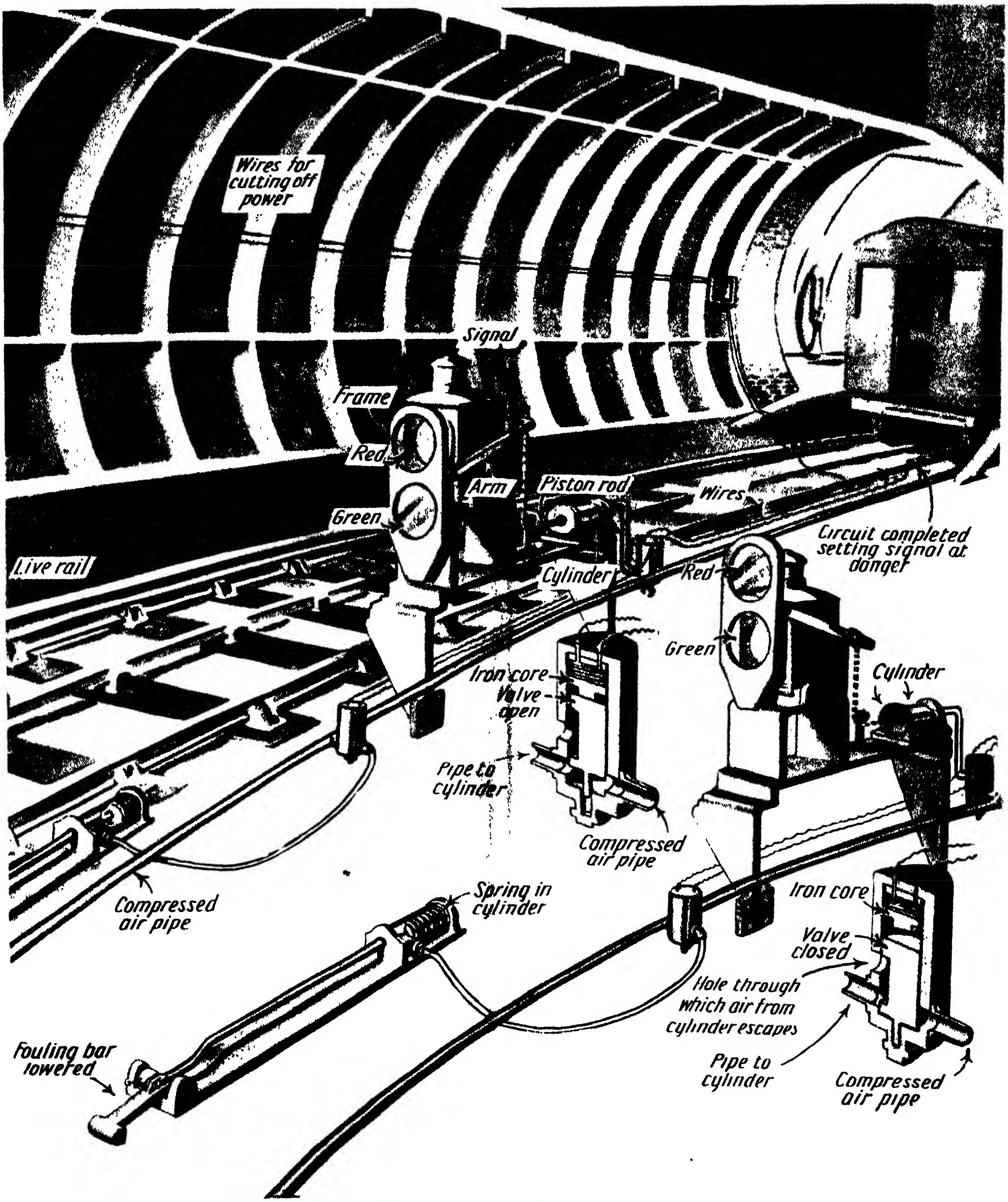
as they turn and so providing them with a path to run on. The caterpillar tractors were first used for hauling agricultural machinery, but in 1915 were developed for military use on the armoured fighting vehicles called tanks. Some six-wheeled road vehicles are fitted with removable tracks. On a good road the tracks are removed and the vehicle travels on its wheels in the ordinary way, but on heavy ground the tracks are mounted over the two pairs of rear wheels. During the 1939-45 War, exceptionally strong tracks and powerful engines to drive them were developed for use on tanks and self-propelled guns. The experience thus gained was adapted to civilian use and haulage tractors are now in service with engines of over 100 horse-power. A caterpillar tractor of this type is illustrated on this and the previous pages. It can pull a load of many tons across the roughest ground.

THE WONDER OF LONDON'S TUBE RAILWAYS:



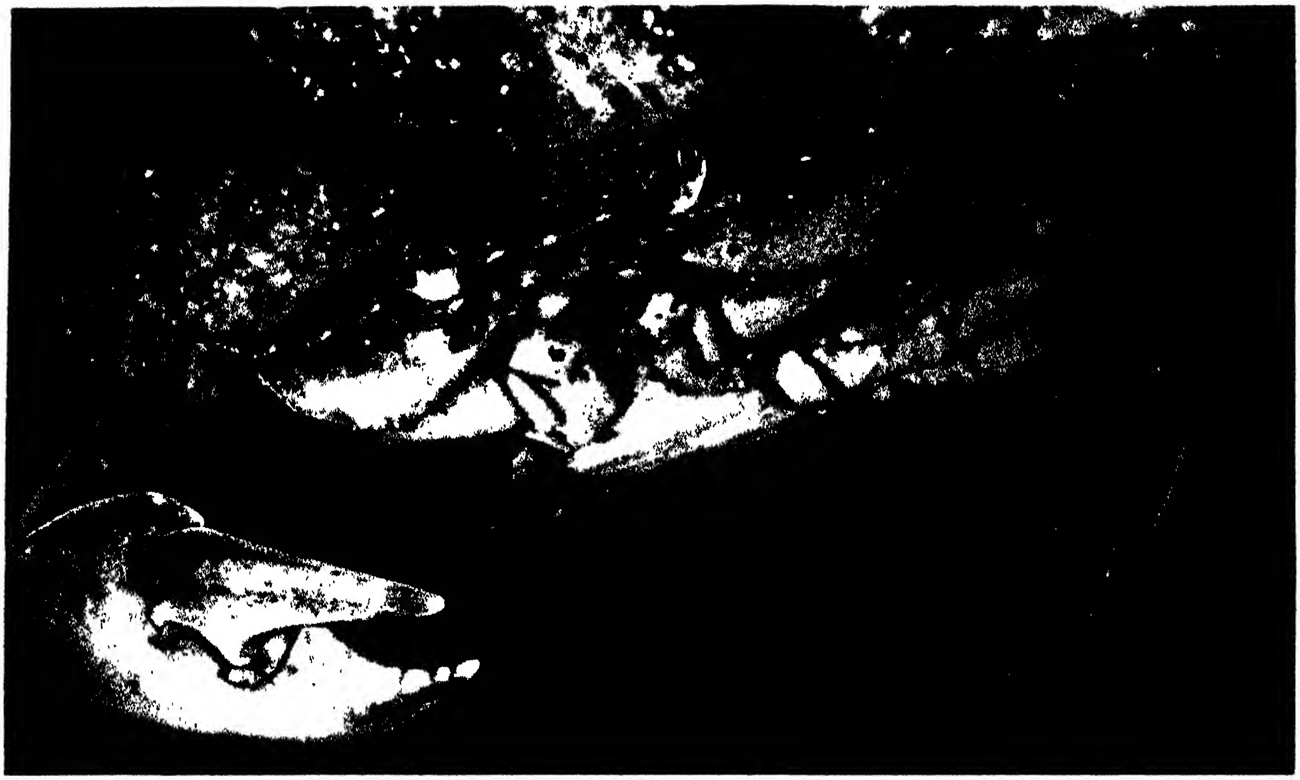
In this picture, which runs across the two pages, we see why, on the London tube railways, the trains can follow one another so closely in safety. The track is divided into sections, and when a train is on the section ahead of another train its back wheels and axle, with the rails and some wires, as shown in the top right-hand, complete a circuit, setting a signal at danger. The completed circuit causes a core of iron at the signal to become magnetised, and this pulls up to it an iron valve, which opens up an inlet, allowing compressed air to go into a cylinder. The compressed air forces back a piston, the outside rod of which is attached to an arm holding a frame with red and green glasses in front of a lantern. The piston rod, on being forced out of the cylinder, lets down the frame, bringing the red glass in front of the light. All this is shown, an enlarged drawing being given of the core, valve and pipe. At the same time the completed circuit made by the train in front has operated a similar magnetic valve still nearer the succeeding train. This lets compressed air from the main pipe at the side of the railway into a cylinder, pushing back a piston. The piston pulls back a long rod, causing a fouling bar to rise. Should the next driver not notice the danger signal, this fouling bar will strike a projection on his train, called a trip cock, and turn it horizontally. At once a tap is opened, letting compressed air escape from the train pipe into the brake pipe (not shown) and at once operates brakes and stops the train. The escaping of air from the brake pipe lowers the pressure and lets fall a

WHY THE TRAINS CAN FOLLOW SO CLOSELY



piston which was holding up a bridge across which wires run from contactors. The bridge drops, the wires are disconnected, and the current is cut off from the contactors. Their cores cease to be magnetised, and bridges which they are holding up then fall, causing a gap in the main circuit, and the motors of the train stop working. Ordinarily the driver does this by working the control handle, which operates "fingers" that break or complete the circuit gradually. When the train ahead has moved off, the circuit made by the axle, wheels and wires is broken, and the iron core of the signal magnet becomes demagnetised and its valve drops, closing the inlet from the compressed air pipe. Air also is let out of the cylinder. The piston returns, pulling the chain and raising the frame, so that the green glass is now in front of the light. At the same time the breaking of the electric circuit, by operating the second valve, exhausts the air from the cylinder holding the fouling bar and lowers that bar. In the bottom left-hand of the opposite page we see the machinery which is operated by the guard for opening and closing the coach doors. On the right of the page we see it as it is with the doors closed. To open the doors the guard raises a lever, which lets compressed air into a cylinder and this forces back a piston attached to a ratchet which turns a cog wheel and moves an arm to draw back the door. In case of emergency the driver, by fixing together two wires that run the length of the tunnel, can cut off all current from the track. These wires are shown in the picture by the side of the tunnel

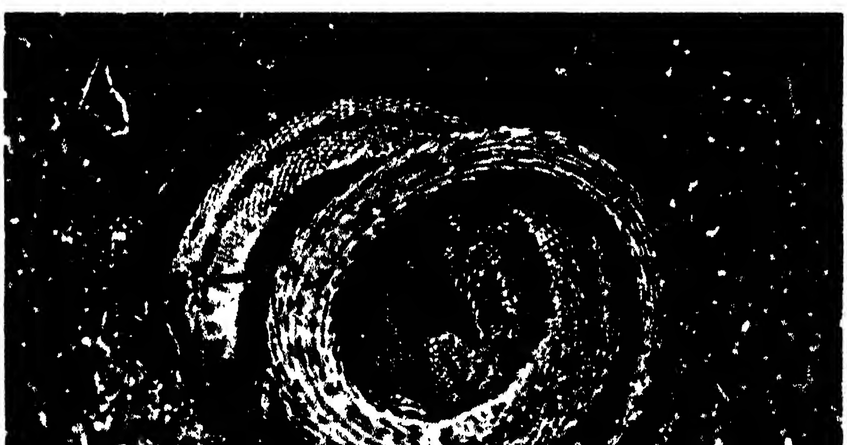
A CRAB WHICH HAS ENORMOUS STRENGTH



The edible crab, a common species round the British coasts, is a creature which, for its size, has enormous strength. It will feign death and then when it has put its enemy off his guard, will seize with its powerful claws any part of him that is near and hold on with the tenacity of a bull-dog. The only thing to do in such a case is to wrench the claw right off the crab and then open it. The crab will hold on till it is killed and its grip is like iron. Further, if a person happens to stoop down and get his hand between the crab's shell and a rock immediately overhead—a position such as is shown in the photograph—the crab will raise itself on its legs pressing the hand between the shell and the rock. The fishermen say that if the crustacean is a big one it can exert such strength as to hold even a strong man a prisoner and he can only release his hand when someone dislodges the crab with a rod or hook. Edible crabs are cannibals and when a well-known naturalist placed a number in an aquarium, the larger ate up the smaller till at last only one, the largest and strongest, was left in the tank. The method of attack was for a crab to seize one weaker than itself and crush its shell with the claws and then devour the victim. Before long the victor would be seized, crushed and eaten by another crab stronger than itself. So the battle went on till only one remained. Fishermen catch the crabs by leaving in the water creels or round baskets containing fresh bait. The crabs enter and cannot get out again. This photograph is by Hug Block, Paris

BRITISH LIZARDS THAT APPEAR LIFELESS IN WINTER

Our British lizards, like the grass snake and adder, hibernate through the winter. When the cold weather comes they retire to holes in trees, to the underpart of stones, or to heaps of dead leaves, and there with others of their species pass the winter in a state of almost lifeless rest. The functions of life are so nearly suspended that none of the outward signs of its existence is visible. The circulation of the blood becomes very slow indeed, breathing apparently stops altogether and digestion certainly ceases to work during the period the lizard is sleeping.



A common lizard apparently lifeless as it indulges in its winter rest. Many people seem to be afraid of lizards, thinking they will do some harm, but they are perfectly harmless and are additional attractions to the fernery where they keep the insects down

But as soon as the warm spring Sun begins to shine, the circulation is restored, breathing again becomes regular and the blood moves in the body. Digestion starts and the little reptile becomes active.

Three lizards are found in England, the common lizard with a brown or olive back with black bands on each side, the sand lizard, the male of which is often green while the female is brown, and the slow-worm or blind worm, which has no visible legs and looks like a snake. All the lizards throw off their skins from time to time, exactly as the snakes do.

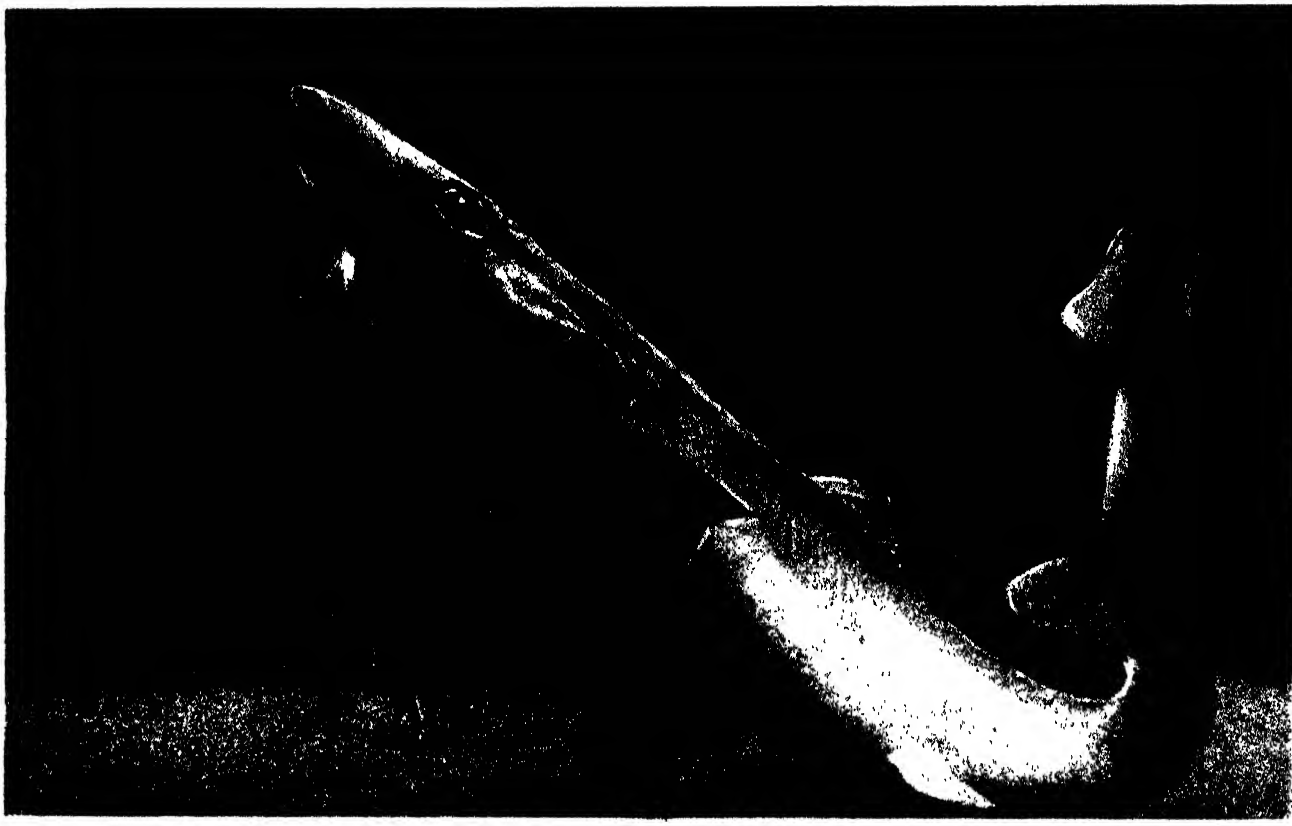
THE LIFE-STORY OF A COMMON BRITISH FERN

Here is the life-story of a common British fern, the Male fern, so-called not because of its sex but because of its robust growth. The first picture shows its form. The underside of each frond is dotted with spore cases called sporangia, which in one year will scatter over a thousand million spores. The spore cases have a wax-like covering, and in due course the wall bursts and discharges the spores, which fall to the ground. Moisture causes a spore to swell and burst, when it sends down a rootlet that forms a flat green growth called a prothallium. On the underside are egg-cells and also male organs. Spiral bodies called cilia from the male organs find their way to the egg-cells, fertilising them and causing a union of cells from which a fern results. This grows and the life-story is repeated

LIFE ON THE EARTH 3,000,000 YEARS AGO

By the time the Eocene Age dawned great changes had come to the life of the world. Many of the old forms of reptiles had passed away for ever, and the mammals had become the dominant type. The remote ancestor of the horse, known as hyracotherium, a little animal the size of a fox terrier (bottom right of picture) made its appearance, and also a curious animal (bottom left) known as phenacodus, which had a tail like a tiger's and combined some of the characteristics of the deer pig, tapir, horse and ape. In the picture, above the phenacodus, we see the horned amblypod, an animal of the rhinoceros type. Above this on the left we see the arsinoitherium also something like a rhinoceros. There were two forerunners of the elephant, one the moeritherium (top left of picture) about three feet high, and the palæomastodon, an animal twice that size, with small tusks and a short trunk. Pigs bigger than wild boars were beginning to appear. One seen on the right of the picture is called the elotherium. Crocodiles, alligators, lizards and snakes were living, and a large variety of sea life, including sharks much like those that live to-day. In vegetation there were trees like our present-day trees, such as oaks, chestnuts, yews, walnuts, limes, alders, willows, firs, pines and cypresses

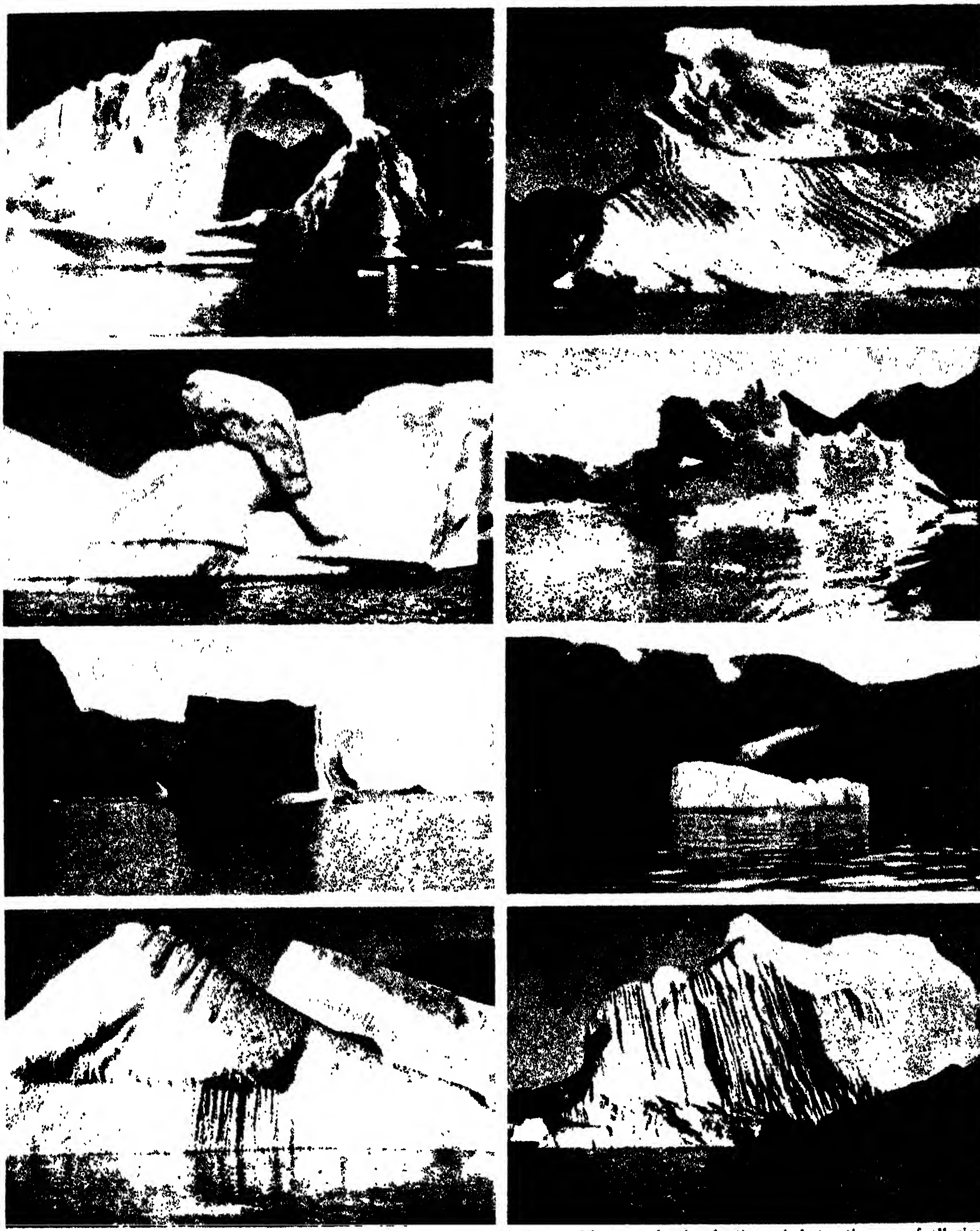
A FIGHT BETWEEN A SHARK AND AN OCTOPUS



The photographs on this page, showing a great fight between an octopus and a tiger shark, were taken from a glass chamber let down with the photographer and camera into the sea at Samarang, in Java. They are part of a film, and here the shark is seizing the octopus

The fight was a fierce one and in the end the shark killed the octopus. These creatures are both bitter enemies of man, but they are mortal foes of one another and fight whenever they meet. It is very difficult to say which would be the more terrible to encounter

ALL SORTS AND FORMS OF ICEBERGS



Icebergs, those masses of floating ice which have broken off from glaciers and ice-caps in the Arctic and Antarctic, are of all sizes and forms. Here we see, in a remarkable set of photographs taken during the relief party's journey to the Wegener Arctic Expedition, some of the different formations of icebergs off the coast of Greenland. They become weathered like other rocks and when we remember that only one-ninth of the iceberg appears above the surface of the water, we can judge of the colossal size of some of these floating masses. Icebergs have been seen with 200 feet above water so that they must have had 1,600 feet below, and their estimated weight has been hundreds of millions of tons. No wonder they are a menace to shipping when they reach the steamship routes

THE DUST IN THE ATMOSPHERE

Dust seems light enough when we see it blowing about in the street on a windy day, but even the finest dust has weight and when a storm is blowing in a dusty region like a desert the weight of dust moved is almost incredible. Sometimes, as we read here, it amounts to millions of tons and may be blown for thousands of miles from its starting place. Some dust is to be found practically everywhere in the world

We can understand that millions of particles of dust should be in the air of great cities and manufacturing districts, for this dust is thrown out by chimneys in such quantities as to shut out a good deal of the Sun's light and heat which should reach us. Of this we read in another part of this book.

It is around the particles of dust in the air that moisture condenses, producing fogs. Here, again, we can understand why there should be fogs in and about our towns and cities. But why should there be fogs and mists in country places, and even on wide plains where there are no houses or fires?

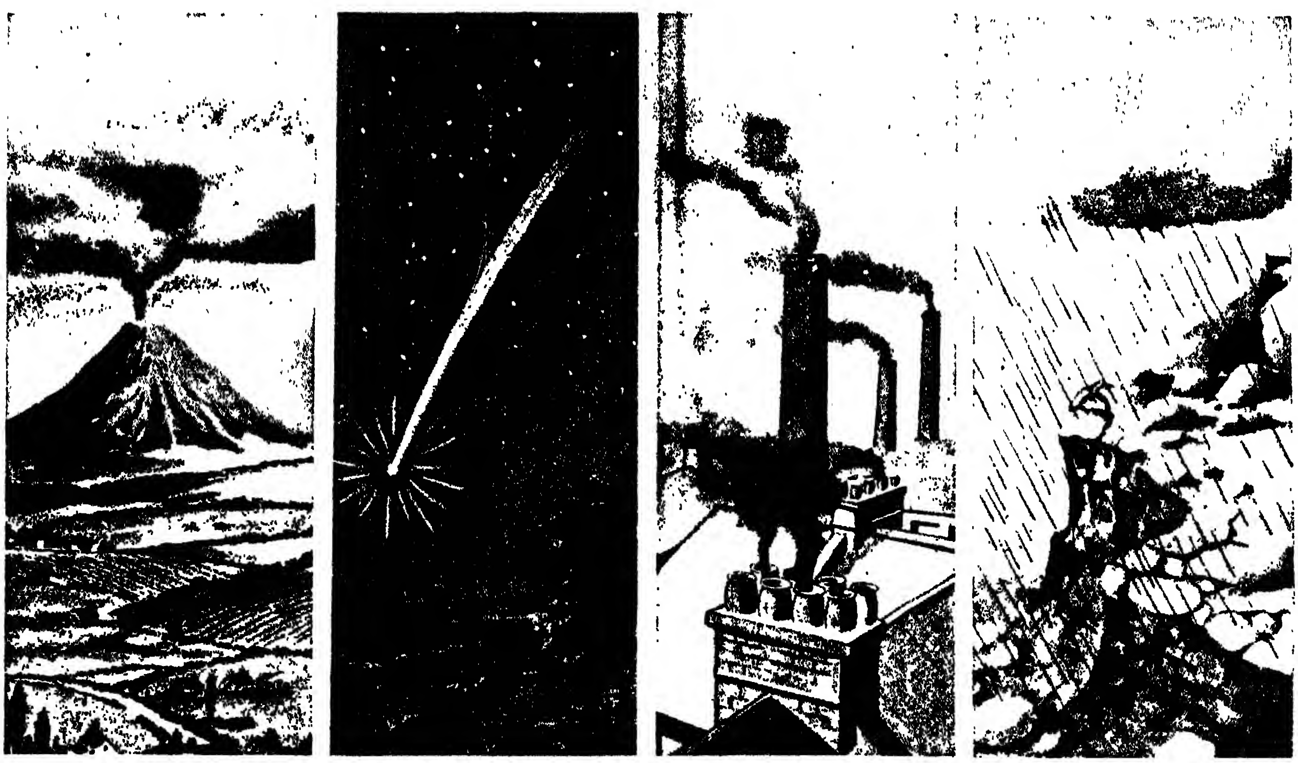
Well, there is dust in the air everywhere. The only place where we can obtain air free of dust is in a laboratory. The dust in the atmosphere comes from all sorts of places. It is blown about and carried up high by the winds. Much of it comes from volcanoes, while some is the result of the weathering of the rocks; and, of course, much of the city and town dust gets into the atmosphere and is carried into the country. Then, higher up is a vast deal of dust which results from the burning up of the millions of meteors which enter the Earth's atmosphere every day.

Distributing the Dust

In all these different ways dust is thrown into the air, and the winds carry it, so that it is well distributed all over the Earth's surface. Of course, much of it falls to the ground, and the heaviest particles fall faster than the very fine ones.

The dust in the atmosphere, if it could be collected and weighed, would undoubtedly turn the scale at millions of millions of tons. In one great area in China there is a loose, fine yellow earth known as loess, which in some places is thousands of feet deep. It is supposed to have been blown to its present situation from the deserts of Central Asia. Smaller deposits of a similar kind are found in other parts of the world.

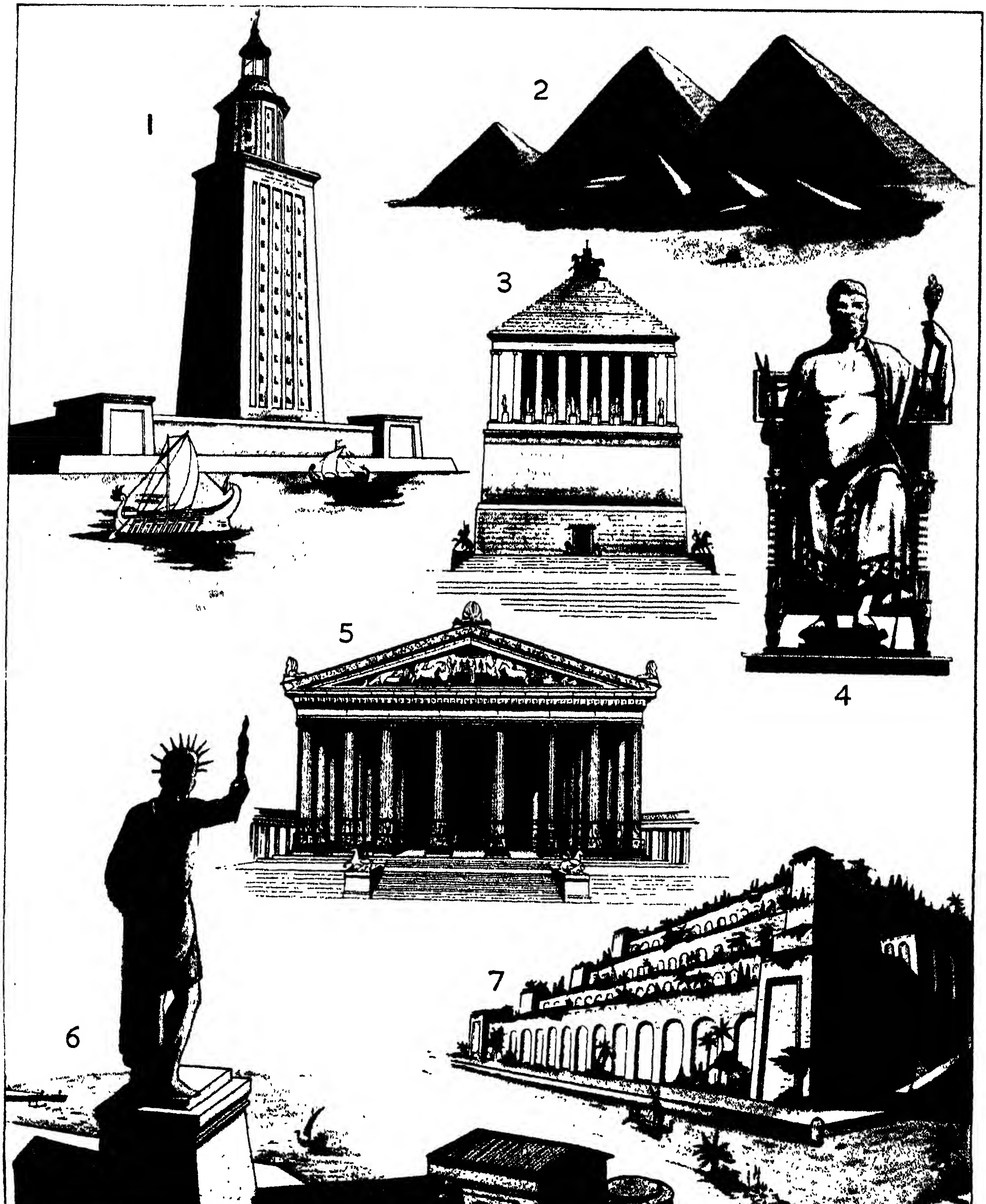
The amount of dust that can be carried, and the distance to which it can be blown by a really fierce storm, is astonishing. A storm that occurred in Northern Africa at the beginning of the present century is said to have blown not less than 1,800,000 tons of dust to Europe and spread it all over the continent, some of it reaching a locality as far as 2,500 miles from its starting-place. During this same storm 150 million tons of dust are estimated to have been deposited on the African coast.



There are four principal sources from which dust gets into the air. It is poured out from active volcanoes, it results from the burning up of meteors as they rush through our atmosphere, it is thrown into the air in enormous quantities from chimneys, both from those of factories and from those of dwelling houses, and it results from the weathering by heat and rain and wind of the crust of the Earth. These pictures show the four sources of atmospheric dust. When we remember that, according to men of science, hundreds of millions of meteors reach the Earth's atmosphere every day we can understand that this is a considerable source of dust

500

THE SEVEN WONDERS OF THE ANCIENT WORLD

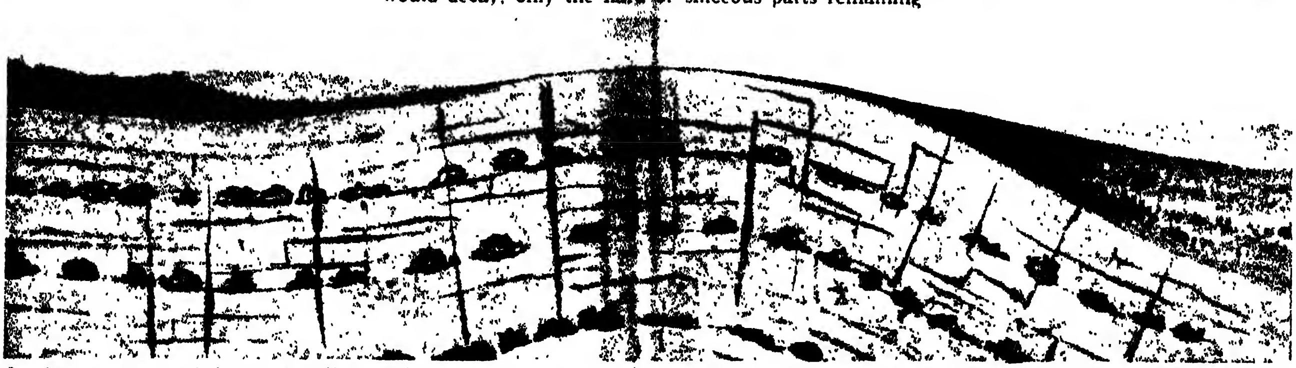


You have often read, or heard people speak, of the Seven Wonders of the World. This drawing shows you what they probably looked like. Of course, they may have appeared rather different from our artist's idea, because all except the Pyramids of Egypt (2) have been destroyed. The six others were: 1, The Pharos or lighthouse at Alexandria; 3, The Mausoleum or tomb of Mausolus at Halicarnassus; 4, The great seated statue of Zeus or Jupiter at Olympia; 5, The Temple of Diana at Ephesus; 6, The Colossus or great statue of the Sun God at Rhodes; 7, The Hanging Gardens of Babylon.

HOW THE FLINTS GOT INTO THE CHALK

Millions of years ago the sea had countless numbers of tiny creatures living in it known as foraminifera These were jelly-like animals that made shells for themselves out of the chalk in the water. As they died they fell to the bed of the sea, where various kinds of sponges were growing, as shown here. These sponges had hard parts or skeletons made of silica

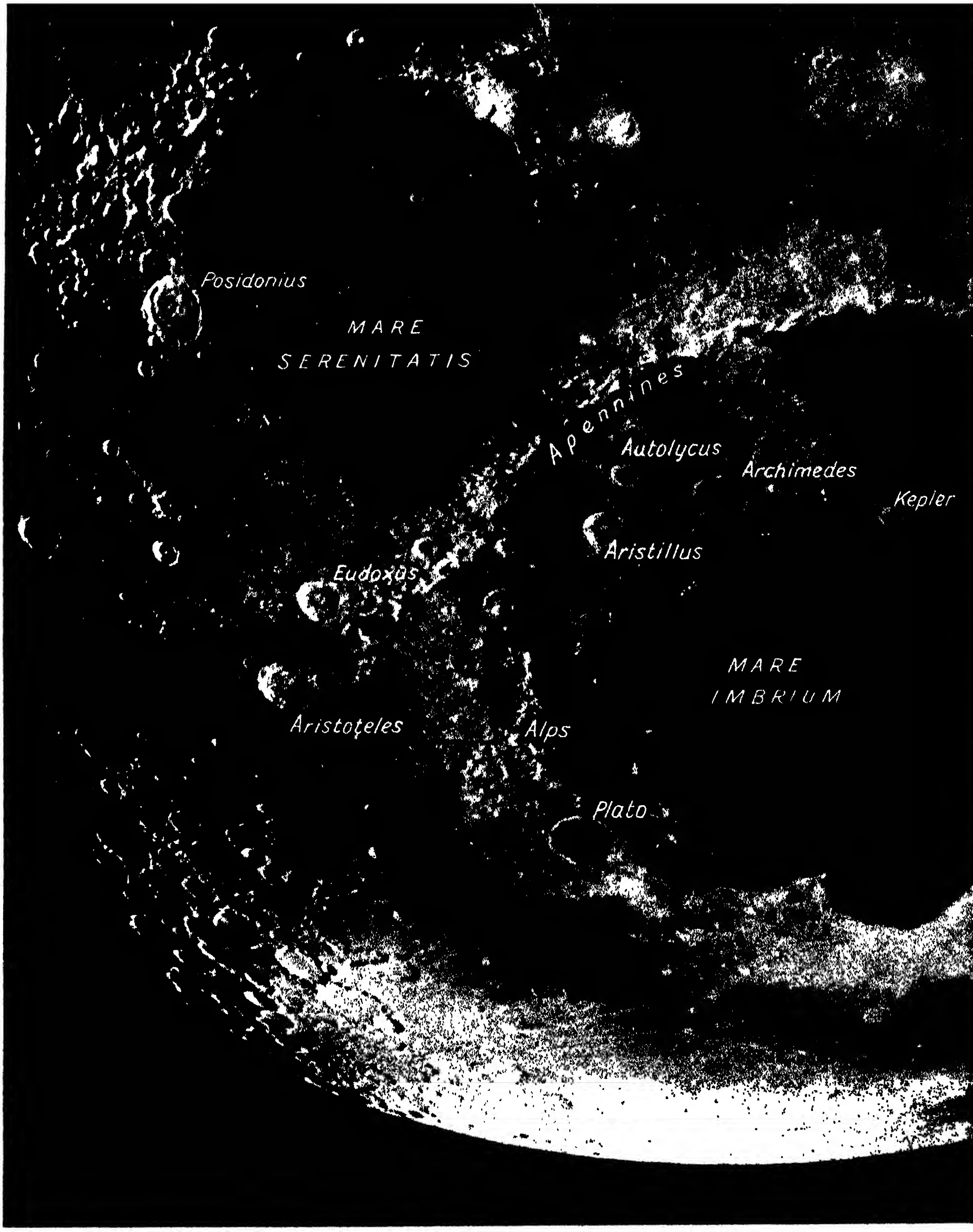
In course of time these sponges died, and were buried under the ever-increasing depth of tiny foraminifera shells constantly falling on the sea-bed. Then as the chalky deposit increased another layer of sponges would grow on the sea-bed and this process might be repeated several times, taking, of course, an enormous number of years in completion. After being buried the soft parts of the sponges would decay, only the hard or siliceous parts remaining



In time the layer of tiny foraminifera shells, now scores of feet thick, was upheaved from the sea, and in the process was cracked in many places. It became the chalk hills and cliffs of the present day. The hard skeletons of the sponges dissolved, and became nodules or masses of flint, which is only a form of silica. Where the chalk was cracked the dissolved silica ran down and filled the cavities

The result of these processes is that we now find horizontal layers of flint nodules where the sponges grew in the sea-bed and vertical collections of flints or isolated nodules where the dissolved silica ran down the cracks in the chalk. Often inside flints we can see traces of the skeletons of sponges. Flint is only another form of rock crystal, and is itself made up of very small crystals. Where the outside of a flint is white this is due to the same cause as the whiteness of snow, the reflection by the crystals of the light that falls on them

THE MOUNTAINS AND PLAINS OF THE MOON



In this fine photograph of part of the moon's surface, taken with the great 100-inch telescope at Mount Wilson Observatory in America, we see the Northern part of our satellite. A photograph taken by means of an astronomical telescope always shows things upside down, so the bottom in this picture is really the top or north as we see it when looking up at the moon with the naked eye. Various features are marked on the photograph including the mountain ranges known as the Alps and Apennines and the great plains called seas, the Mare Serenitatis or Sea of Serenity, and Mare Imbrium or Sea of Rains. A number of very big craters are also named

THE MARVEL OF THE MOVING HEAVENS

It was a long time before men came to realise that the movements of the stars which they could see as they watched the heavens night after night were due, not to these distant bodies travelling round with the Earth as a centre, but to the Earth itself rotating on its axis and revolving round the Sun. Here we read many interesting things about the moving heavens

It is to be feared that not many people nowadays, in civilised countries at any rate, look up at the sky at night. In towns this is partly due to the fact that very little of the sky is to be seen owing to the high buildings on both sides of the streets. Yet a great deal of fascinating interest can be obtained by examining the night sky and watching the stars.

In the old days most people used to examine the heavens. No doubt this was largely owing to the fact that so many of them were shepherds, and as they watched their flocks by night like the Shepherds of the Gospel story, they looked up because the points of light above them were the only things of interest to be seen.

Watching the Stars

By watching the stars night after night in this way ordinary men with no knowledge of science learnt a great deal about the movements of the stars, and we may do the same if we will only take the trouble to watch the sky at night, fairly regularly for a year or more. We shall soon discover that there is a procession of the stars apparently in a westward direction.

It is all very well to read about things in books, but it is much more interesting to discover things for ourselves, and we may all become amateur astronomers and gain a great deal of knowledge by an intelligent watching of the sky.

The Night Sky Moves Round

On some clear night when darkness has fallen let us face south and notice what stars are to be seen due south and well up in the sky. A week or ten days later on another clear night let us examine the sky in exactly the same direction. We shall notice that the stars which were immediately south are now some distance to the west.

These stars and all the others near them seem to have moved in a westward direction towards where the Sun set some hours earlier, or we might perhaps think that the Sun had moved eastward towards these stars.

Of course, when the Sun is shining brightly in the heavens in the daytime we cannot see the stars, but if we could we should notice that the Sun approached and passed by certain stars near his path day by day. This path of the Sun among the stars is called the ecliptic, and we read about the ecliptic on page 755.

The apparent movement of the stars and of the Sun past the stars is really due to the Earth's movements. As we know, the Earth has two main movements. It turns round on its axis once in every 24 hours, and as it does so the heavens seem to go round in the sky and come back more or less to the same place the next night. But in addition to this apparent movement of the stars round and round every 24 hours, there is the other apparent movement to the west.

Now in the old days when men of science supposed the Sun was a comparatively small ball of fire not so very many miles away, and that the stars were merely points of light in a great hollow ball also only a few hundreds of miles away, it was natural that they should think that the Sun and the stars were all circling round the Earth.

An Impossible Idea

In those days man thought the Earth was the most important of all the heavenly bodies, because he lived upon it. When, however, it was realised that the Sun was tens of thousands of miles away and that the stars were glowing giants millions of miles away, it was understood to be impossible

If we stand a lamp on a table in the centre of a room as shown in the first picture and then walk round it facing the lamp all the time, we shall see that the lamp appears to move round and pass the objects on and against the walls. Now if we stand in the centre of the room and get a grown-up friend to walk round us carrying the lamp, and as it goes keep facing it, we shall get the same effect, the lamp passing the objects against the walls. These experiments show the difficulty men had in discovering whether the heavens moved round the Earth or whether the apparent movements of the stars were due to the Earth's movements

that these could all be rushing round the Earth in 24 hours. The speed at which they would have to travel would have to be so enormous—in some cases millions of miles a second—that they could not possibly move at such a rate and still retain their form. It was much more reasonable to suppose that it was the Earth that moved and that the apparent motion of the Sun and stars was due to the Earth's movement.

When we are travelling in a railway train at sixty miles an hour and look out of the window we see the various objects in the country apparently rushing past us in the opposite direction, and those that are near seem to be travelling very rapidly, while those farther away appear to move more slowly. As we sit still in the train the illusion that we are stationary and these things are rushing past is perfect.

Sometimes in a railway station when another train is alongside ours and one of them begins to move slowly, we cannot be sure for a time whether we are still and the other train moving, or whether we are moving and the other train is stationary. Now this helps us to understand the movements of the heavenly bodies. Let us carry out two simple experiments which will assist us still more.

In a large room we place a lamp in the centre and walk round it in a direction opposite to that in which the hands of the clock move, keeping our face towards the lamp all the time. As we go round the table on which the lamp stands, we shall notice that the lamp seems to move round and pass the objects that are against the wall, the chairs, pictures, and so on. In this experiment the lamp stands for the Sun, the objects against the wall for the stars, and we represent the Earth.

Now once again, instead of walking round the lamp let us stand in the middle of the room and get a grown-up friend to carry the lamp round us in the direction opposite to the hands of a clock. As he does so, we keep turning our head so as to face the lamp and keep our eye upon it. We shall notice that the effect is the same as when we walked round the lamp. The light seems to move round passing the objects against the wall, as it did in the previous experiment.

From these experiments we see that it is impossible from the mere appearance of the Sun and stars to know whether they are moving round us or we round them. It is by other methods, as we read on page 928, that we know that the Earth is moving round the Sun in an orbit, and that as it travels not only the Sun, but the distant stars as well, seem to go round.

How the Stars Move Westward

If we notice the position of any particular star or group of stars at the same hour, say nine or ten o'clock, once every week or ten days, we shall find that the stars get farther and farther west at each observation. Some of them indeed disappear altogether below the horizon for a considerable period, but if we continue our observations for a year or more, we shall find that all the stars will repeat their apparent movements. The star or constellation that appeared due south at a certain point on, say, January 1st, and travelled farther and farther west will on the succeeding January 1st be back in its old position in the south. The reason is that the Earth has travelled right round the Sun in its orbit and has started on another round.

A photograph of part of the heavens exposed for two hours, showing how the stars appear to travel as the heavens circle round, each star forming a line on the plate

Apparent Motion of the Heavens

A person dancing the old-fashioned waltz and moving round and round, unless he were used to it, might fancy the room with its walls and furniture were turning round in the opposite direction from that in which he was going. This is another illustration of the apparent movements of the stars.

As the axis of the Earth, if prolonged indefinitely into Space, would go very near the position where the Pole Star is, the whole of the heavens, as the Earth turns round on its axis, seems to circle round the Pole Star. This apparent rotation of the heavens is due to the rotation of the Earth on its axis. As already explained, the change in the position of the stars farther and farther westward, till they return once more to their old place in the heavens, is due to the Earth's revolution round the Sun in the course of a year. It is as though the whole sky, like a great umbrella, turned round over the Earth in 365¼ days.

Monsieur Camille Flammarion, the great French astronomer, gives us another illustration to make the matter simple. "If," he says, "we walk round a fountain or a grass plot we see all the details of the neighbouring region in succession. Suppose we are in Trafalgar Square, London, walking around Nelson's Column. When we have Whitehall and the Statue of Charles the First on our right (Nelson's Column being on our left), we see in front of us the entrance to Northumberland Avenue.

"As we walk around the Square we find ourselves looking down the Strand, and a little farther on we pass St. Martin's Church on our right. On continuing our circuit we soon observe on the right hand the National Gallery and on the left hand across the Square we can just see along Whitehall; while in front we look towards the College of Physicians. After a few steps more we pass Cockspur Street on our right and then return to our original position with Whitehall on the right.

"If we make a second tour the same aspect of our surroundings will present itself to us in succession. It should be observed that in walking in a circular or nearly circular direction such as the above, it would be impossible to see at one glance St. Martin's Church, the National Gallery, the College of Physicians, and the view down Whitehall.

"Now, during the yearly circular journey of the Earth round the Sun the same thing happens to us as regards the stars. As our globe advances describing a curve, we discover fresh stars and those we saw before seem to glide away from us into the west—that is, behind us as regards the direction of the Earth's motion. The various starry regions file before us in succession, and at the end of a year the positions of the stars again appear to us as they did at the beginning."

Of course, the experiment which Monsieur Flammarion suggests can be carried out in a playground.

THE LAST OF THE GREAT NAVIGATORS

Captain Cook was one of the greatest of the world's circumnavigators and not only his own country but seamen of all races and nationalities owe him a great debt of gratitude for showing the way to abolish scurvy, that terrible scourge of the mariner in the old days. In these pages is told the story of Cook's three famous voyages to the South Seas and of his discoveries there

A YEAR or two before the Great War it was suggested by some scientists who had been making a particular study of foodstuffs that natural foods contained very minute quantities of unknown substances which were essential to life and health.

During the War, when much time was given to research, the existence of several of these mysterious substances was discovered, and they were called "vitamins," from the Latin word "vita," meaning "life." But although their existence was known the substances themselves could not be found or seen. Much has been learnt about them since, as we read on pages 711 and 712.

Now it is a very interesting fact that about a century and a half before modern science learnt of the existence of the vitamins, a great Englishman had discovered the fact, although he himself did not know there were such substances. This may seem a paradox, but it is nevertheless true that Captain James Cook, the great English explorer and navigator, discovered by experiment that fresh green foods had something about them that made them vital to a healthy life.

A Scourge of Mariners

Up to that time a terrible disease known as scurvy had been the scourge of all mariners. Every crew that went to sea for any length of time suffered from it, and on an average about a third of the men died from it, while on very long voyages half the crew perished.

It was Captain Cook who showed the real and effective way of combating scurvy, and the whole world owes him a debt of gratitude for his great contribution to civilisation. We know now that it was the lack of vitamins in the food which caused this terrible disease among sailors. By landing wherever he could and collecting fresh fruits and vegetables, Captain Cook provided his men with the necessary vitamins that overcame the scourge and kept his men healthy.

Cook was really a very wonderful man. In an age when many captains acted with great brutality to their crews, Cook, though a strict disciplinarian, was always kind and considerate. At a time when it was considered perfectly justifiable for the white man to treat natives with no consideration at all, in fact as though they were less than human, Cook always regarded the rights of the people at whose lands he called, and it is one of the great ironies of history that he of all men, who was the true friend of the natives, should have been slain by them in the end.

James Cook was the last man one would have expected to become a great circumnavigator and explorer. He was the son of an agricultural labourer and, with very little education, had his earliest training as a worker in a haberdasher's shop in Yorkshire.

From the very first Cook did his best to get fresh vegetables and fruit for his crew

He spent only a year or two at the village school before he went, at the age of twelve, to a shopkeeper at Staithes, a fishing village not far from Whitby. But young Cook did not want to be a haberdasher, he wanted to be a sailor.

There is a story of those early days, how he stole a shilling from the till of his master, packed up his luggage in a pocket-handkerchief, and ran away to Whitby, where he found a ship on the point of sailing, and offering his services as cabin-boy, was accepted. It is quite a pretty little fairy-tale, but it is not true.

What really happened was this: Cook, seeing a new shilling in the till, took it out, replacing it by one of his own. His master missed the bright shilling and searched his box, where he found it. Then he sent for a constable and for Cook's father, and charged the boy with theft. But young Cook declared with spirit his entire innocence, and explained the matter, whereupon his master expressed his regret, and although Cook's father and the haberdasher both pressed him to remain, he replied: "No, father, I can't. Once a thief, always a thief. I must go."

Apprenticed to the Sea

Seeing that the boy was determined to go to sea, his employer introduced him to a member of a shipping firm, and to his great joy Cook was apprenticed. It was the first step in a career of honour and adventure which has ever since proved an incentive to English boys of all ages.

Cook made his first voyage in a coasting vessel, the *Freelove*, which carried coal, and on this young Cook must have learnt his earliest lessons in seamanship. Between the trips up and down the East Coast Cook used to stay at his employer's house. When his period of apprenticeship had expired he went before the mast for three years, still on vessels sailing out of Whitby. Then he became a mate.

But Cook had made up his mind to enter the Royal Navy. Thousands of men were being seized for service by the press-gangs, but Cook volunteered, and was accepted. Within 37 days he had been made master's mate, and this position he held for a couple of years. He saw active service, and was then given the rank of Master in 1757, when he was 29 years old. He had thus

risen to the rank of master in the very short time, for those days, of two years. He was appointed to a ship named the *Pembroke*, and sailed with Admiral Boscawen's fleet to America.

It is interesting to know that his ship was one of those that assisted Wolfe during the campaign that ended in the taking of Quebec and the conquest of Canada. Cook did a good deal of surveying in the River St. Lawrence, and in piloting vessels and boats of the fleet. It is said that he provided the admiral with a chart of the soundings in the river which proved of the greatest value.

While engaged in the operations before Quebec Cook had a narrow escape from being captured by the Red Indians. His party, while surveying, was suddenly attacked by a flotilla of canoes that had dropped silently and unseen down the stream. The Englishmen only escaped by making a dash for the Isle of Orleans, where the guard turned out and drove off the enemy It is said that Cook's escape was so narrow that he only jumped ashore from the bows of his boat as an Indian boarded her at the stern. It was fortunate for the world that the young master mariner did not lose his life on this occasion.

Cook at Quebec

There is no doubt that some of the success of the English at Quebec was due to Cook. He was promoted to a larger ship, the *Northumberland*, and how good his work was is proved by the fact that Lord Colville, who had been appointed commander-in-chief of the North American station, entered in his journal that he had " directed the storekeeper to pay the Master of the *Northumberland* fifty pounds in consideration of his indefatigable industry in making himself master of the pilotage of the St. Lawrence." Whatever Cook did he always did well.

For several years he was engaged in surveying in and about the St. Lawrence and the shores of Newfoundland, and in the winters he spent his spare time in educating himself in all matters that would be of service to him in his naval career. He read Euclid and studied the higher mathematics and astronomy. Then when the *Northumberland* returned to England in 1762 Cook was discharged

Lord Colville wrote to the Admiralty: " I beg to inform their Lordships that from my experience of Mr Cook's genius and capacity I think him well qualified for the work he has performed and for greater undertakings of the same kind."

In that year Cook married, and then he went to live at Shadwell and finally at Mile End, in the East End of London. The house does not exist to-day, but it was in what is now the Mile End Road.

Cook now went out to Newfoundland and continued his survey work, and while he was there a horn of gunpowder which he had in his hand exploded. It was some time before Cook could receive proper medical attention, but he did not let it interfere with his survey work. He bore a large scar on his hand to the day of his death.

Then Cook returned to England, and now the great work of his life began with the first of his three long voyages to the South Seas

The natives of Tahiti presented Cook and Banks with green boughs in token of friendship

It had been calculated by the astronomers that a transit of Venus, that is a passage of the planet Venus across the Sun's disc, would occur in June, 1769, and the Royal Society decided that several expeditions should be sent to different parts of the world to take observations. The British Government was asked to supply a ship to carry a party of observers to some of the islands of the South Seas, and it agreed.

It was reckoned that the voyage would take about two years, and Cook was selected to command the expedition. A Whitby-built ship called the *Endeavour* was chosen, and was manned with 85 men, including 12 marines.

Cook was given the rank of first lieutenant, and in addition to being in command of the vessel was appointed one of the two observers of the transit. A distinguished botanist, a Fellow of the Royal Society, and later known as Sir Joseph Banks, went to make observations in natural history Banks was a rich man, having a private income of about £6,000 a year

On the 7th of August, 1768, Cook joined the ship and sailed from the Thames, and on the 14th the vessel called at Plymouth, where Joseph Banks and another scientist went on board.

Cook's secret orders commanded him to sail for Otaheite, now called Tahiti, an island of the Society Archipelago. Then, after making various astronomical observations, he was to sail south and see if he could find the supposed southern continent, which was always described as Terra Australis Incognito, or the Unknown Southern Land, which everybody believed to exist. If he found no land he was to explore New Zealand and then return to England by any route he thought proper

The Expedition Starts

The expedition finally left England on August 26th, with 94 persons on board, 18 months' provisions, 10 carriage guns and 12 swivel guns, with a large quantity of ammunition and stores of all kinds.

At Madeira a fresh supply of water, beef, vegetables and wine was taken on board. Cook from the very beginning was scrupulous in keeping his boat clean and in looking after the diet and health of his men. Strangely enough we find that two of his men, a marine and a sailor, were given 12 lashes each for refusing to eat their allowance of fresh meat. Of course this seems rough treatment for such an offence, but at that time the lash was regarded as the only method of punishment in the Navy and was used for offences both trivial and serious. Cook knew how important it was that scurvy should get no hold on his crew, and he had come to realise that diet was an important preventive.

From the very first Cook did his best to get fresh vegetables for his crew, and at Madeira he took in a very large supply of onions. When off Teneriffe a shark was caught and cut up into steaks for dinner, which the scientists reported as very good. The men, however, refused to eat this food from superstitious motives.

As an example of Cook's thoroughness it may be mentioned that when a list of all on board was drawn up, even the dogs and cats were included.

There was a good deal of fun in crossing the line, all those who had not done so before having to pay homage to Father Neptune or to purchase

immunity with four days' allowance of wine We do not hear that Lieutenant Cook was ducked, but most of the others were

The *Endeavour* called at Rio de Janeiro, where its officers and men were not treated very well by the Portuguese authorities The Viceroy expressed a doubt as to whether the vessel were a King's ship at all He seemed quite unable to understand the object of the voyage, and accused the crew of smuggling As an illustration of his ignorance Cook tells us that his only idea of the transit of Venus was " the North Star passing through the South Pole." Eventually, however, the vessel was allowed to obtain stores and then sailed south.

Sighting Tierra del Fuego, it passed through the Straits of Le Maire, Banks and another scientist named Dr. Solander landing at Staten Island and returning with a collection of a hundred new plants, most of which were unknown in Europe.

A party landed on Tierra del Fuego, but unfortunately two were lost and frozen to death. Running short of food, the rest of the party had to shoot a vulture, which was divided up, each one cooking his own portion, amounting to about three mouthfuls. In the end the party, with the two exceptions, got back to the ship.

A Tree in Mid-Ocean

Even thus early in his expedition Cook, who seems to have had great powers of intuition, came to the conclusion from observing the state of the sea and its currents that the supposed southern continent did not exist.

Leaving the southern point of America, he sailed on into the Pacific, and on March 24th saw a tree trunk floating, which suggested that the ship was not far from land. Cook, however, did not deviate from his course, and it is now believed that he passed near Pitcairn Island, which afterwards became the home of the Bounty Mutineers.

Finally, on April 12th, the ship reached Tahiti, where the natives appeared friendly and supplied large quantities of fruit and vegetables, including bread-fruit, bananas and coconuts.

Cook and Banks, with others, landed and received presents of fowls. They were allowed to stroll about, and the natives presented them with green boughs in token of friendship. But the people were great thieves. During dinner Dr. Solander had his pocket picked and an opera-glass taken, while another scientist lost his snuff box. After some trouble these objects were eventually recovered.

The natives, says Cook, were "prodigious expert" in stealing, and the greatest difficulty was experienced throughout the stay in looking after all loose goods They even tried to steal the anchor.

But Cook was very unlike some commanders of other nations. He ordered that every means was to be taken to cultivate the friendship of the islanders, and commanded that they were to be treated " with every imaginable humanity." All, however, were not as careful as Cook, and on one occasion when a sentry was pushed over and had his musket stolen, a midshipman ordered his men to fire, and the thief was hit.

A Fort for an Observatory

Cook now built a camp or fort, surrounding it by a bank and ditch on two sides and by a palisade on the other sides Two carriage guns and six swivel guns were taken ashore to defend the camp, and there was a garrison of 45 men. Then the astronomical instruments were landed and placed in their proper positions ready for the observation of the transit.

Captain Cook. From the well-known painting by Sir Nathaniel Dance-Holland

One of the friendly natives complained that he had been poisoned by something given him by a sailor, and when Banks made inquiries he found that the man had bitten off a piece of tobacco from a quid which had been given him and swallowed it. Banks ordered large draughts of coconut milk to be taken as an emetic, and soon the native was quite well again.

Flies proved a very great pest, and when a mixture of tar and molasses was placed as a trap to catch them, the natives stole the mixture and used it as an ointment.

A blacksmith's forge was set up in camp and the natives continually brought old iron to be made into axes. Still the thieving went on, and Cook's stockings were one night stolen from under his head, where he had placed them for safety.

At last came the transit, and Cook writes : " The third of June proved as favourable to our purposes as we could wish. Not a cloud to be seen the whole day, and the air was perfectly clear, so that we had every advantage we could desire in observing the whole passage of the Planet Venus over the Sun's Disk. We very distinctly saw the atmosphere or Dusky Shade round the body of the Planet, which very much disturbed the time of contact, particularly the two internal ones." The heat was very great and proved trying to the observers.

While the officers were engaged in this important scientific duty some of the crew broke into the store and stole a large quantity of nails, which they used in barter with the islanders. One man who was found with nails in his possession was sentenced to two dozen lashes. This was the severest sentence that Cook meted out during the voyage, and was really extraordinarily light for those days.

Dog for Dinner

June 5th, which was King George the Third's birthday, was celebrated by Cook entertaining a number of chiefs at dinner. Unfortunately, these natives drank the King's health so often and with such zeal that they brought trouble upon themselves.

In return the chiefs presented a dog to the English commander, which had to be cooked and eaten ; and Cook tells us that these dogs lived entirely on vegetable food, and that in flavour their flesh was " next only to English lamb."

The object of the visit to Tahiti having been accomplished, the boat was careened, that is, turned on one side for scraping and caulking. She was then varnished and the other boats painted white, and after stores and water had been taken on board she sailed south to make a further search for the southern continent, although, as already explained, Cook did not believe it existed. Finding nothing of the kind, the *Endeavour* came to the east coast of New Zealand.

Before leaving Tahiti, Cook had laid out gardens and sown the seeds of melons, oranges, lemons, limes, mustard, cress, and other European fruits and vegetables, which he had taken out in sealed bottles.

The Dutch explorer Tasman had discovered the west coast of New Zealand in 1742, but had never landed. The first one of Cook's crew to sight the land was a boy named Nicholas Young, and Cook, who had ready wit in naming places, called this point Young Nick's Head.

Here the natives proved hostile It appears that when they first saw the

ship they thought it was a very large bird, and they were struck by the size and beauty of its wings, that is, the sails When they saw the unfledged young bird—the boat—leave its side filled with human figures of different colours, they thought it was a house hold of gods It was unfortunate that right at the beginning, when some shots were fired to frighten them, two or three natives were killed

However, some trading was done, and then the New Zealanders seized a Tahitian boy who had joined Cook's ship and refused to give him up. At last, though very reluctantly, the order was given to fire on the canoe containing the boy Several New Zealanders were killed and the boy, seeing his chance, jumped into the sea and swam to the ship, where he was picked up Cook therefore named the point where this occurred Cape Kidnappers Another place, where the natives, appearing hostile, were frightened off by the firing of a shot, Cook christened Cape Runaway

A Transit of Mercury

Throughout the voyage careful scientific observations were made, and while the ship was at New Zealand a transit of Mercury occurred, and was witnessed and notes of the times of contact recorded

At one place Cook named a river the Thames, because he thought it looked like the river that he had left when he started his long voyage

When Cook found his crew committing offences against the Maoris he punished them, and three men were given a dozen lashes each for stealing.

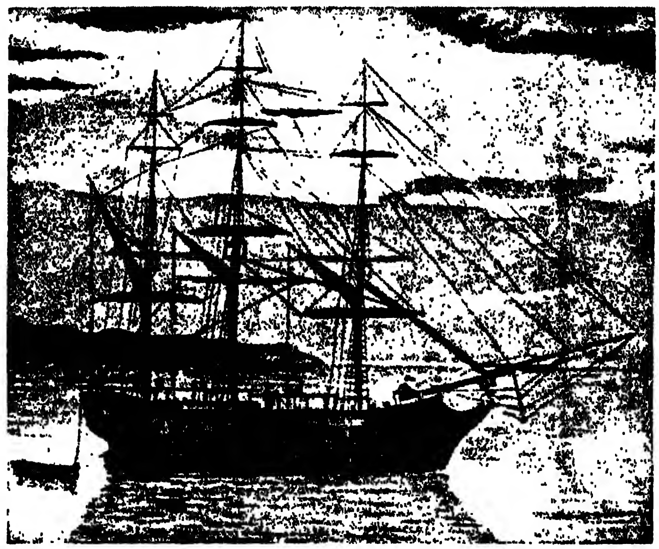
Christmas Day came in 1769 and some solan geese were killed and made into a pie, which was "eaten with great approbation," and we are told "in the evening all hands were as drunk as our forefathers used to be upon like occasions." Cook found proof that the Maoris practised cannibalism at times

Eventually on March 27th he writes: "As we have now circumnavigated the whole of this country it is time for me to think of quitting it." The scientists of the expedition had come to the conclusion that European fruits and grain would grow well in New Zealand, and that an agricultural population would flourish there

So well did Cook chart the New Zealand coasts and seas that the commander of a French expedition sent out the next year spoke most highly of the work, and said that he found it of an exactitude and of a thoroughness of detail which astonished him beyond all power of expression. "I doubt," said he "whether our own coasts of France have been delineated with more precision," and he decided to follow Cook's chart absolutely

Cook now resolved to return to England by the East Indies. He knew that the Dutch had discovered a great mass of land somewhere to the west, but he had no idea whether he could sail round the top of it to Java. He named the last point of land of New Zealand Cape Farewell, and after sailing for three weeks sighted the coasts of Australia

Travelling north, he landed at a place south of what is now Sydney, and called it Botany Bay, because so many new kinds of plants were found there. Then he sailed north, was nearly wrecked on the Great Barrier Reef, and took possession of the whole eastern coast "in the right of His Majesty King George the Third, by the name of New South Wales."



The *Resolution*, the ship in which Captain Cook sailed round the world on his second and third voyages

He sailed through Torres Straits, proving that Australia and New Guinea were separate lands, and crossing the Indian Ocean and rounding the Cape of Good Hope he anchored in the Downs on July 13th, 1771, after being away three years and having sailed round the world

An Immortal Bustard

While Cook was in Australia a bustard weighing 17½ pounds was shot, which proved useful for food, and the bird is immortalised in the names of Bustard Bay and Bustard Head When the *Endeavour* struck on the barrier Reef the name of Cape Tribulation was given to the point In this way the romance of the great voyage is recorded in the names of the places at which the *Endeavour* touched.

During the voyage in the South Seas the travellers saw the Aurora Australis, or Southern Lights.

The great wonder of the voyage, however, is that up to the time of reaching Batavia, in Java, the ship had been marvellously free from disease of any kind, particularly scurvy The surgeon reported that only five cases had occurred during the voyage, a report such as had never before been made by one of His Majesty's ships after a voyage of considerable length This was declared by the surgeon to be undoubtedly due to the careful forethought and constant attention of the commander to everything, no matter how trivial.

Unfortunately the immunity from disease did not continue. Batavia was a malaria-ridden region. In twenty years there had been over a million deaths there from malaria and dysentery, and while in Java a number of Cook's men became infected and died.

Cook was very generous when he got home in praising his officers and men and recommending different ones for recognition and promotion He always gave full credit to everyone, and he was invariably beloved by his crews

The Second Voyage

The question of the existence or non-existence of a great Antarctic continent was still regarded as unsolved, and so in 1772 Cook was sent out once more on a second great expedition of exploration This time he had two new ships, the *Resolution* and the *Adventure*, his old vessel the *Endeavour* having returned to Whitby to do collier work once more

Joseph Banks the scientist declined to go on this expedition, because he did not approve of the type of ship that was chosen, and so a German naturalist with the English name of John Forster was appointed. He was not a pleasant person, and seems to have made the chief aim of his life during the voyage and afterwards the belittling of Cook. He did nothing but complain from the time he left England till the time he returned.

Dr. Joseph Priestley, the great scientist who discovered oxygen and the composition of water, was also invited to join the expedition as astronomer, and expressed his willingness to do so, but in those days of bigotry some clergymen who happened to be members of the Board of Longitude objected to his inclusion on religious principles, because Dr. Priestley was a Unitarian.

It is very difficult for us in these days to think of a distinguished scientist being barred from a post for which he is eminently fitted on scientific grounds because of the particular faith which he holds, but such things happened in those days. Dr. Priestley therefore did not join Cook.

The expedition left Plymouth on July 13th, 1772, and after calling at the Cape of Good Hope, went south in search of the Antarctic continent. The vessels cruised about and went down below the Antarctic Circle, when they were driven back by masses of ice, which at one time completely blocked the ships. They took lumps of ice on board and melted them for use as fresh water.

In the fog the vessels became separated. Cook, being unable to find the *Adventure*, sailed for New Zealand, and proceeded up the west coast. One day he saw six water-spouts, one of which came within fifty yards of the vessel. At Queen Charlotte Sound in the north of South Island he found the *Adventure* once more.

While at New Zealand Cook landed in secluded spots a pair of goats and a boar and sow, hoping that before these were seen and hunted by the natives they might increase in number. A ram and ewe also were landed, but the next day they were found lying dead, and it was believed they had eaten something poisonous.

Leaving New Zealand, Cook sailed for Tahiti once again, where he obtained fresh meat and vegetables. The natives behaved fairly well, except that one of them picked up the coconuts from which the sailors had extracted the milk, filled up the openings very skilfully, and sold them a second time to the crew.

Seeking a Continent

The ships left Tahiti and cruised for many months in the South Seas, calling at various islands and still looking for the Antarctic continent, which they never found.

Cook sailed again to New Zealand, but lost sight of the *Adventure*, which he never saw again till he reached home, when he found that his companion ship had been back in England for nearly a year.

Cook himself was away for about three years, and in part of the voyage experienced very rough weather. We are told that in December, 1773, when the ship was in the neighbourhood of the Antarctic Circle, "icicles frequently hung to the noses of the men more than an inch long," and that the men were "cased in frozen snow as if clad in armour."

In all his attempts to go farther south Cook was stopped by floating ice. On March 11th, 1774, the *Resolution* called at Easter Island, where Cook landed and found the natives wearing European hats and jackets, which they were said to have received from Spaniards who visited them four years earlier. The gigantic statues for which this island is famous were noticed. At this time Cook suffered from a bilious fever, probably brought on by the cold.

At many of the islands at which the expedition called the natives proved great thieves. They seized anything they could lay their hands on, and one man even tried to cut the line that held the sounding lead so as to obtain the metal.

At some places trouble was experienced, and guns had to be fired to frighten the people. Sailing round Cape Horn and crossing the South Atlantic, Cook anchored in Table Bay. He landed and called on the Dutch Governor, who did all he could to assist the English navigator. Fresh food was provided, and then Cook sailed for home, arriving at Plymouth on July 29th, 1775, to find that the attention of the English people was occupied with the American Colonies.

The boy, seeing his chance, jumped into the sea and swam to the ship, where he was picked up

Cook had made many important geographical discoveries during this voyage, and the maps which he prepared are practically those which are used to-day, though, of course, many further details have been added. Out of 118 men on board the *Resolution* only one had died of disease. It was the first time such a wonder had happened.

To honour Cook's contribution to hygienic science the Royal Society presented him with the Copley Gold Medal, its highest award. Cook was promoted to the rank of Captain in the Navy, and on July 12th, 1776, he sailed on his third and last long voyage of exploration.

He went himself in the *Resolution* once more, and an accompanying ship, the *Discovery*, sailed with him. They went round the Cape of Good Hope, sailed south to Australia, and called at New Zealand and Tahiti, and then sailed north up the Pacific to see if a passage could be found round the north of America back to the Atlantic.

After calling at the Hawaian Islands they travelled up the west coast of America, round Alaska and through the Bering Straits. At one place they landed and found the natives great thieves. Everything of metal that could be stolen was taken. Fish-hooks were cut from their lines, and iron, brass and copper fittings were taken from the boats.

"Before we left the place," says Cook, "hardly a bit of brass was left in the ship, except what was in the necessary instruments. Whole suits of clothes were stripped of every button, bureaux, etc., of their furniture, and copper kettles, tin canisters, candlesticks, etc., all went to wrack, so that these people got a greater medley and variety of things from us than any other people we had visited."

Water in the Oil

The people were cunning in other ways, for they were found adding water to the bladders of oil which they sold to the crew. At another place a native who was allowed to go into Cook's cabin carried off his watch, but it was recovered later.

Cook cruised about between the American and Asiatic shores of Bering Strait, going north just beyond Icy Cape in Alaska, which is beyond the 70th parallel of latitude, and then, being unable to penetrate farther, he turned back and called at the Sandwich Islands (now known as Hawaii) proposing to stay there for the winter and make a detailed survey of the islands.

He arrived on January 17th, 1779, and after staying a fortnight and being very well received, he himself being treated almost as a god, he set sail once more on February 4th. Encountering very bad weather and finding his fore-mast sprung, he returned, and anchored in Karakakoa Bay once more.

The whole behaviour of the natives now seemed changed. They thieved more boldly, and were both surly and insolent. The carpenter's tongs were stolen twice in one day, and the pursuit of the thief led to a severe skirmish.

The English established a camp for scientific observation on the shore

while the ship was being repaired, and during the night the sentries had to be doubled. Under cover of darkness some natives stole the *Discovery's* cutter, and Cook went ashore to see the head men and get the boat returned. Some of their canoes were pursued, and Cook with a party of marines landed and marched to the chief's village, where he was received with the usual marks of respect.

This chief seemed friendly, but a large crowd of natives gathered round and showed insolent hostility. Cook wanted to take the chief on board his ship, and the man seemed willing, but the natives would not allow this. Then shots were heard coming from the other side of the island, and it turned out that a party from the *Discovery*, in trying to prevent some canoes from getting

The Death of Captain Cook at the Sandwich Islands, now known as Hawaii From the painting by G. Carter

away, had had to fire on them, and a chief of high rank had been killed.

The natives now became very excited, and it was seen that they were sending their women and children away. Things looked serious, especially when a man with a stone in one hand and an iron spike in the other came up to Cook in a threatening manner.

Cook tried to calm him, but he became more excited, so Cook fired a charge of small shot at him. He was not injured, as the mat clothing he wore protected him. Then some stones were thrown at the marines, and a chief tried to stab one of the officers, who thereupon knocked him down with the butt end of his musket.

So threatening had the natives become that Cook fired the second barrel of his gun, which was loaded with ball, and killed one of the natives. A shower of stones was at once thrown at the white men, who replied with a volley.

They were about to reload their guns when there was a rush of natives, and four Englishmen were killed, others being wounded. An officer was stabbed, but before the blow could be repeated he shot his assailant.

Cook, who was at the water's edge, turned round to tell the boat's crews to stop firing and pull in to the shore. As long as he faced the natives they did not touch him, but as soon as his face was turned one struck him on the head, and another stabbed him in the back.

He at once fell with his face in the water, and then there arose a great shout from the natives, who rushed forward and dragged the English commander up the beach, stabbing him again and again. The other Englishmen rushed into the water and made for the boats.

Five men, including Captain Cook, had been killed, and as it seemed impossible to recover their bodies, the boats put off. Then the boats were recalled from other parts of the bay, and a strong force was landed to bring off the party who were still at the camp.

The natives gathered in force, but the guns were turned on them and there was no further trouble. The foremast of the *Resolution* was on the shore when the trouble broke out, but the crew, with the help of the force that had been landed, managed to get it aboard. It was on February 14th, 1779, that Captain Cook met his death.

Later on, natives arrived with white flags and asked for peace, and some of them brought gifts of breadfruit, sweet potatoes, and so on. The friendly advances, however, were intermingled with hostile demonstrations, and after provisions had been obtained and what could be recovered of Captain Cook's body had been committed to the deep, the ships sailed for home. It is said that some of the murdered commander's bones were long afterwards preserved as sacred relics in Hawaii.

It would seem that the attack on Cook was not planned out, but was simply the result of a sudden outburst of rage at the punishment of the thieves. This makes the sad end of the great commander all the more tragic.

During this third voyage a good deal of use was made of fireworks, to impress the natives, and displays were given at various stopping places.

The *Resolution* and *Discovery* returned to England by a long voyage round the coast of Kamchatka and Alaska, and back via Japan, the Sunda Strait between Sumatra and Java, and the Indian Ocean and Cape of Good Hope. They arrived back in the mouth of the Thames on October 4th, 1781, having been away four years, two months and 22 days.

But it was a tragic home-coming. The great commander had done the work he had been sent to do, and had done it well, but he himself was no more.

He had, however, done more than mapped the oceans. He had shown navigators for all time how they could sail the seas for thousands of miles, remaining away for years at a time, and yet keep healthy. It is scarcely an exaggeration to say that Captain Cook's work has resulted in the saving of hundreds of thousands of lives on the high seas.

THE ATOM AND ITS ENERGY

Science is one long procession of marvels, and the greatest marvel of twentieth-century science has been to release the energy that had remained locked in the atom since the universe began thousands of millions of years ago. Not only does the release of atomic energy promise to place at man's disposal an inexhaustible source of industrial power, but it has realised the alchemists' dream of transmuting metals. Unhappily, the first use of atomic energy was as the most destructive weapon of war ever devised; but, as you can read in pages 1057 and 1058, its peaceful uses are many. If man can be sane enough, the splitting of the atom will benefit the world. Here you read how scientists released the vast power of the atom; drawings on pp. 494-95 and 1128-29 show how this power can be used to generate electricity.

As you can read in the article on elements on page 1141, all matter is atomic in structure. But although an atom is the smallest portion of matter capable of entering into chemical combination or of being chemically separated, it cannot generally maintain a separate existence except in a few kinds of atoms.

Physicists have established that there are less than 100 different kinds of atoms. Atoms have a very complicated structure made up of positive and negative electric charges so that electricity is basically atomic.

All atoms consist of three kinds of particles: electrons, protons and neutrons. The electron is a minute particle of negative electricity and, when separated from the atom, is purely electrical and almost without mass. The weight of an electron is much smaller than that of the lightest atom; one hydrogen atom weighs as much as 1,840 electrons.

The proton is the electrical opposite of the electron, having an equal but positive charge and a slight mass. The neutron has no charge, but it has the same mass as the proton; consequently, the mass of any atom is the sum of the masses of all the protons and neutrons contained in it.

Protons and neutrons of an atom are held together in a compact nucleus about which the electrons travel in orbits, in much the same manner as do the planets round the sun in the solar system. Although the nucleus is small compared with the dimensions of the atom, its bulk constitutes the main mass of the atom. The diameter of the atom is about 20,000 times that of the nucleus, while the size of the electron is approximately that of the nucleus.

Electrons nearest to the nucleus are more or less tightly bound to it, but those on the fringe, or outer orbits, are comparatively free and able to move from atom to atom throughout a substance. It is these freely-moving electrons that are believed to be responsible for the conduction of electricity through substances.

With some atoms, the outer, or comparatively free-moving electrons, are more closely bound to the nucleus than in others. These are the atoms making up the molecules of substances having a poor electron flow; e.g., the substances from which electrical insulators are made. Atoms in which the outer electrons are loosely held are more free to move from atom to atom, so that the electronic flow constituting an electric current may easily be induced. These latter atoms make up the molecules of the substances which are good electrical conductors.

The atom, although containing protons and electrons, is mostly made up of empty space. Scientists tell us that if we could press the protons and electrons together and do away with the empty space inside the atoms, the material in all the ships of the world's navies could be put inside a woman's thimble—and leave space to spare.

In all normal atoms the sum of the proton charges equals the sum of the electron charges, so that the atom is electrically-balanced; like a magnet with equal pole strengths. The number of electron charges, which always remain equal to the positive charge of the nucleus, varies from element to element. These atomic electrons, whatever their number in any one atom, are responsible for the binding of the various atoms together into the complete molecules of chemical compounds, and for the character of the light emitted by the different kinds of atoms.

As they are electrical systems, atoms have energy, but this energy is not constant. Thus the atoms in the filament of an incandescent lamp only emit light, which is a form of energy, when excited by the passage of an electric heating current; when the current is switched off the atoms lose their energy.

Electrons can be removed from an atom without very great difficulty, as by an electric spark. This process also takes place in very hot gases. It happens in the stars, and also in the cathode of a radio valve; in the latter instance the electrons are separated from the atoms of the cathode.

Separating an electron from an atom leaves the atom ionized, or temporarily converted into an ion with an effective positive electrical charge due to the unbalanced electrical state the atom has acquired. Ionization may be effected through striking against other fast-moving atoms; by the application of intense electric fields; or by light of suitable wave-lengths. Removing electrons from atoms requires considerable energy because of the electrical attraction between the electron and the positively charged remainder of the atom; it is not, therefore, a source of practical or useful energy.

Certain of the heaviest atoms, however, emit radiations called radio-

activity from the atomic nucleus. These atoms have nuclei which are unstable and tend to break up, expelling when they do so particles of high energy. These particles are usually positively charged and they carry some of the charge on the nucleus, so that the nucleus remains with a smaller charge, consequently the remaining atom retains fewer electrons and becomes an atom of a chemically different substance.

This changing of one substance into another is not new, but has been going on in nature ever since there were radio-active substances, but on a very slow scale. The development of nuclear fission, which enables the disintegration of radio-active elements to be speeded up and controlled, makes possible useful and large-scale use of atomic energy.

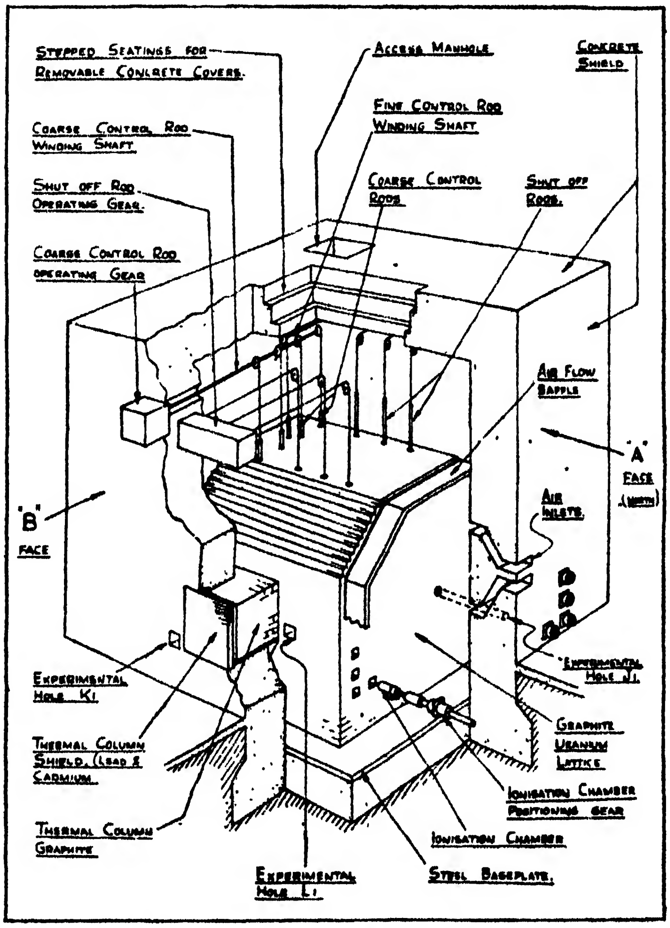
The first step in the development of atomic power was in 1939 when a German chemist, Otto Hahn, began to bombard pieces of uranium with streams of neutrons. Uranium was the largest atom then known, with 92 protons in its nucleus and 92 electrons round it. Hahn hoped to get a neutron to stick inside the nucleus, which he thought would then throw out one unit of negative electricity in the form of an electron, and so turn into the nucleus of a totally new element with 93 protons. As it happened the uranium atoms did nothing of the sort; they split in two, and in place of the totally new element he was looking for, Hahn found only the two well-known elements barium and krypton.

But this splitting of a nucleus into two more or less equal parts, which is called nuclear fission, was at once recognised as a matter of great importance, for two very good reasons.

It was known that a uranium nucleus actually weighed more than the parts into which it broke up, and according to a theory of another German scientist, Albert Einstein, if mass disappeared in this way, very large quantities of energy indeed would be produced. The splitting of the nucleus was also important because the uranium atom when split was found to produce, besides the two main fragments, several free neutrons as well. If each of these was capable of making a fresh atom split up, then the process could obviously go on indefinitely, and the problem of releasing energy from the nucleus of the atom would be solved.

There was one main difficulty. For the most part only slow-moving neutrons can split uranium atoms. The neutrons produced by the split, however, are nearly all fast-moving. When they hit a uranium nucleus they usually penetrate inside and stay there; they are said to be absorbed.

The problem, therefore, was to find some substance which would slow these fast neutrons down without absorbing them, so that they could in their turn split up fresh uranium atoms. Two substances only were found useful for this purpose: one was heavy water; the other, graphite.



This diagram shows you what it is like inside the atomic pile G.L.E.E.P. The initials stand for Graphite Low Energy Experimental Pile. G.L.E.E.P. is at the Atomic Energy Research Establishment, Harwell, Berkshire. As the diagram clearly shows, all operations inside the pile are carried out from a distance by remote control; this is to protect the scientists from the dangerous radiations during the process of atomic fission. A photograph of G.L.E.E.P is on page 1058

The first atomic pile or nuclear reactor to be used for civilian engineering purposes was BEPO, the larger of the two experimental piles at Harwell, Berks. This contains something between 28 and 40 tons of uranium in the form of rods thrust into holes in a mass of 850 tons of pure graphite. Fast neutrons coming out of one rod are slowed down by the graphite to below the speed at which they would get absorbed by uranium atoms. By the time they enter the next rod, they are going at just the right speed to split up more uranium atoms there; and the process goes on indefinitely.

To stop it from working too fast and blowing itself up, there are also a number of cadmium rods which can be thrust into the pile or pulled out at will. Cadmium has the special property of absorbing almost any neutron which gets into it; so when the number of neutrons begins to grow too rapidly, the cadium rods are pushed in automatically to mop some of them up.

The energy released takes the form of heat; so blasts of air are blown through cooling channels in the graphite, and the hot air when it comes out is used to heat water for radiators.

At Areo in Idaho, the heat from a reactor has been used to drive an electric generator. This was a purely experimental affair, however, and the British reactor at Calder Hall, Cumberland, was the first to produce electrical energy for industrial purposes.

The first reactors were made from ordinary uranium. But about one in every 140 atoms of uranium is of the special kind called uranium —235 which can be split up not only by slow neutrons, but by moderate and fast neutrons as well. If the uranium used in a pile is made with more than the natural proportion of uranium —235, then the amount of graphite necessary can be reduced.

A reactor can also be run in such a way that a lot of neutrons are absorbed by uranium atoms. When this happens the new element neptunium is produced, which in due course changes of its own accord into an atom of plutonium. Plutonium, as it happens, has the same properties as uranium —235; so that this type of reactor will sometimes make as much new fuel (plutonium) as it uses up in the form of uranium — 235.

Reactors have also been made with heavy water instead of graphite. In this case it is not necessary to have the uranium in rods: it can be in the form of a radium salt dissolved in the water. These "water kettles" can be much smaller than graphite piles, and it is

believed that they are the ones likely to be used for ships and submarines.

One of the great troubles of generating atomic power is that the more powerful the reactor the more deadly the radiation it gives off. A reactor giving a power of 100 kW has to be screened with at least 10 feet of concrete before it is safe to come near it. This will always be one great drawback to the use of atomic energy for driving land vehicles or any but comparatively large ships and submarines.

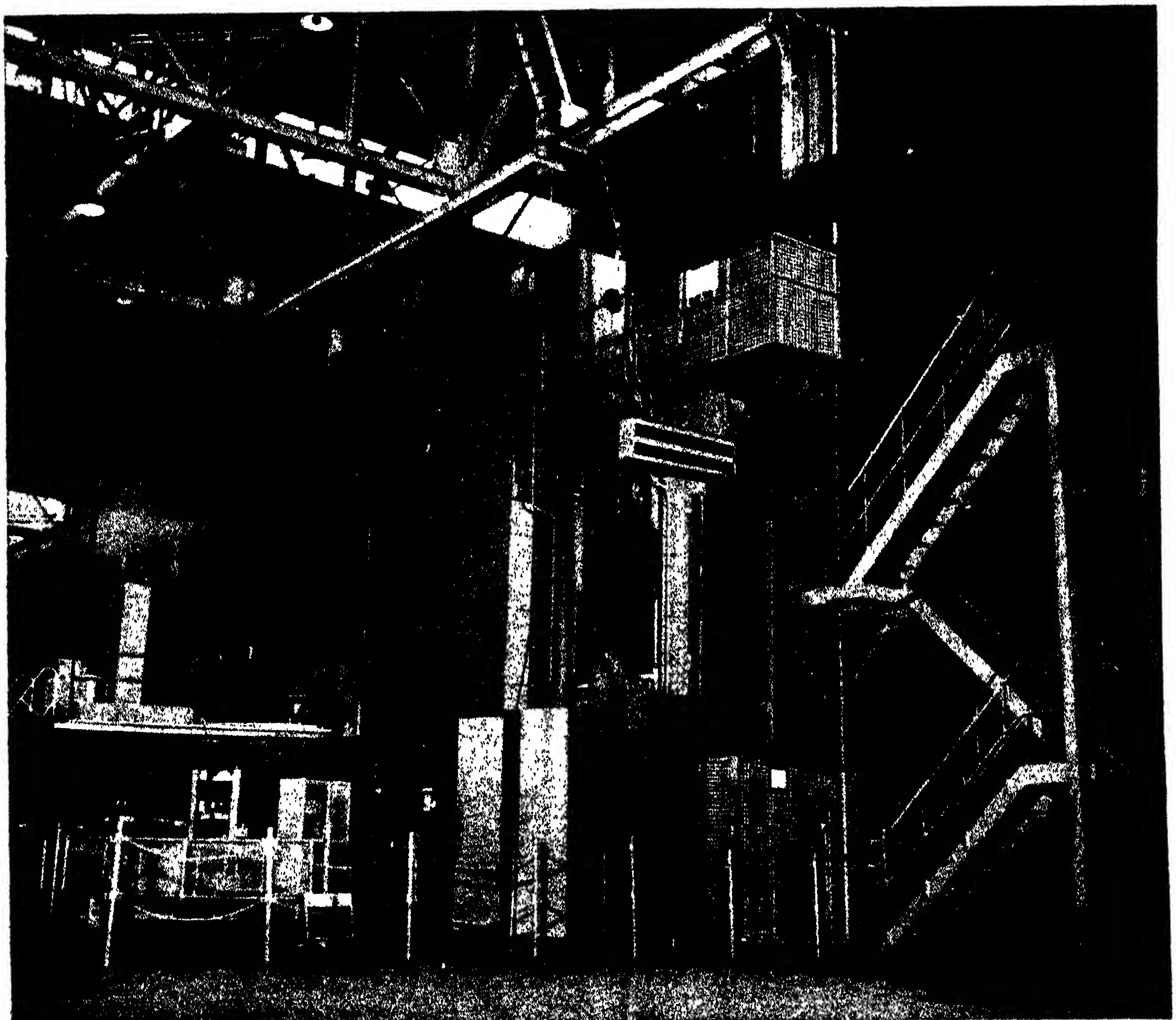
Perhaps the most promising peaceful application of atomic energy is to use it for the generation of large-scale industrial power. By means of heat withdrawn from a nuclear reactor by a liquid metal, enough steam pressure can be produced to drive a turbine which in turn drives an electric generator. It must be remembered, however, that a nuclear reactor is not in itself a motive force; that is, it does not replace a mechanical source of energy such as a steam engine.

Atomic energy is simply a form of fuel, and before it can do useful work it must heat the boiler of a steam engine, and the steam then drives a dynamo. Unfortunately, the capital cost of nuclear reactors is very high, while uranium is very scarce and dear. But one ton of uranium has the power value of a million tons of coal.

But there were many other difficulties. One was to find engineering materials which will not disintegrate under intense radiation.

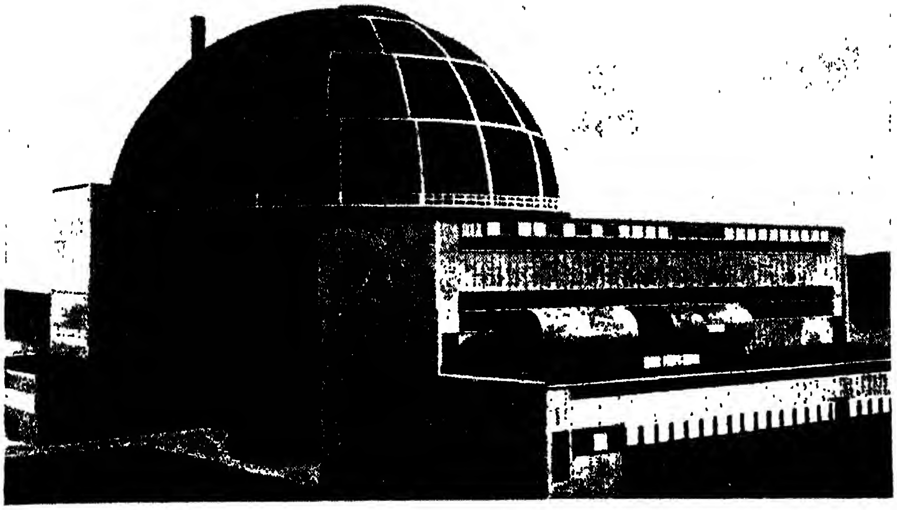
All these problems were solved by the United Kingdom Atomic Energy Authority, and in 1954 the British government announced plans to have in operation a dozen nuclear power stations by 1970. The first of these stations, which is described and illustrated on pages 494–95 was opened at Calder Hall, Cumberland, on October 17, 1956. This was the first full-scale atomic power station in the world, and now supplies electric power to a wide area of the north-west of England.

The industrial use of atomic power has now passed from the experimental to the practical stage. In 1957 the United States Navy had in service the first of a fleet of seven submarines driven by atomic-powered engines, and plans were being made to build for the British Merchant Navy a large cargo vessel driven by similar engines. Both the U.K. and the U.S.A. have conducted experiments in atomic-powered aircraft, and railway engineers are thinking of atomic-powered locomotives.

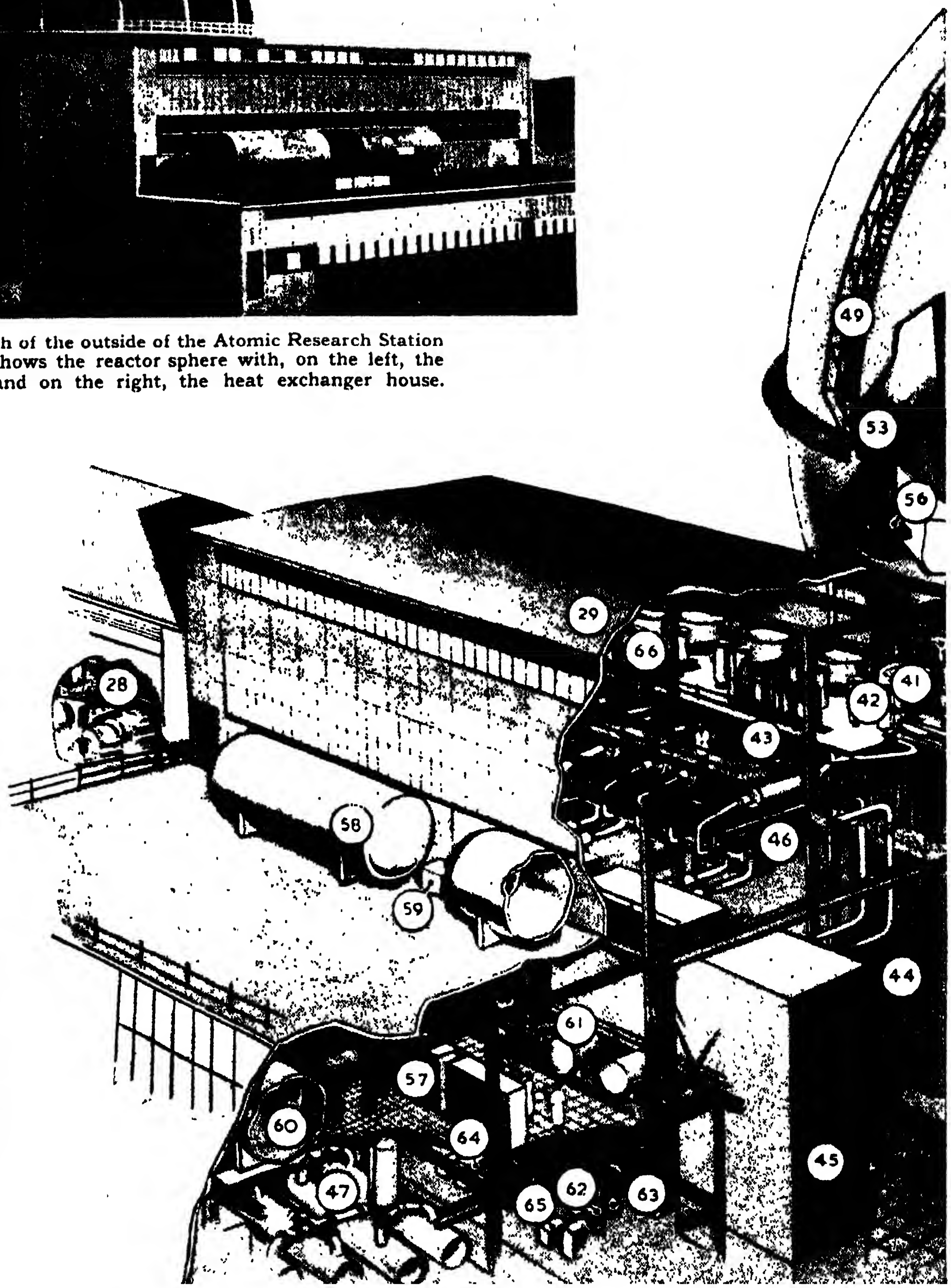


In this photograph you see the outside of BEPO, another pile at the Harwell atomic research laboratories. BEPO is an abbreviation for British Experimental Pile. Some idea of the size of the pile can be obtained by comparing with it the man going up the stairs on the right. Only part of the pile is above ground, and underneath the equipment on the left is a control room giving access to the pile face below ground level. On page 1058 you will find a photograph of G.L.E.E.P., the smaller of the two piles at Harwell.

ATOMIC POWER STATION THAT "BREEDS" MORE



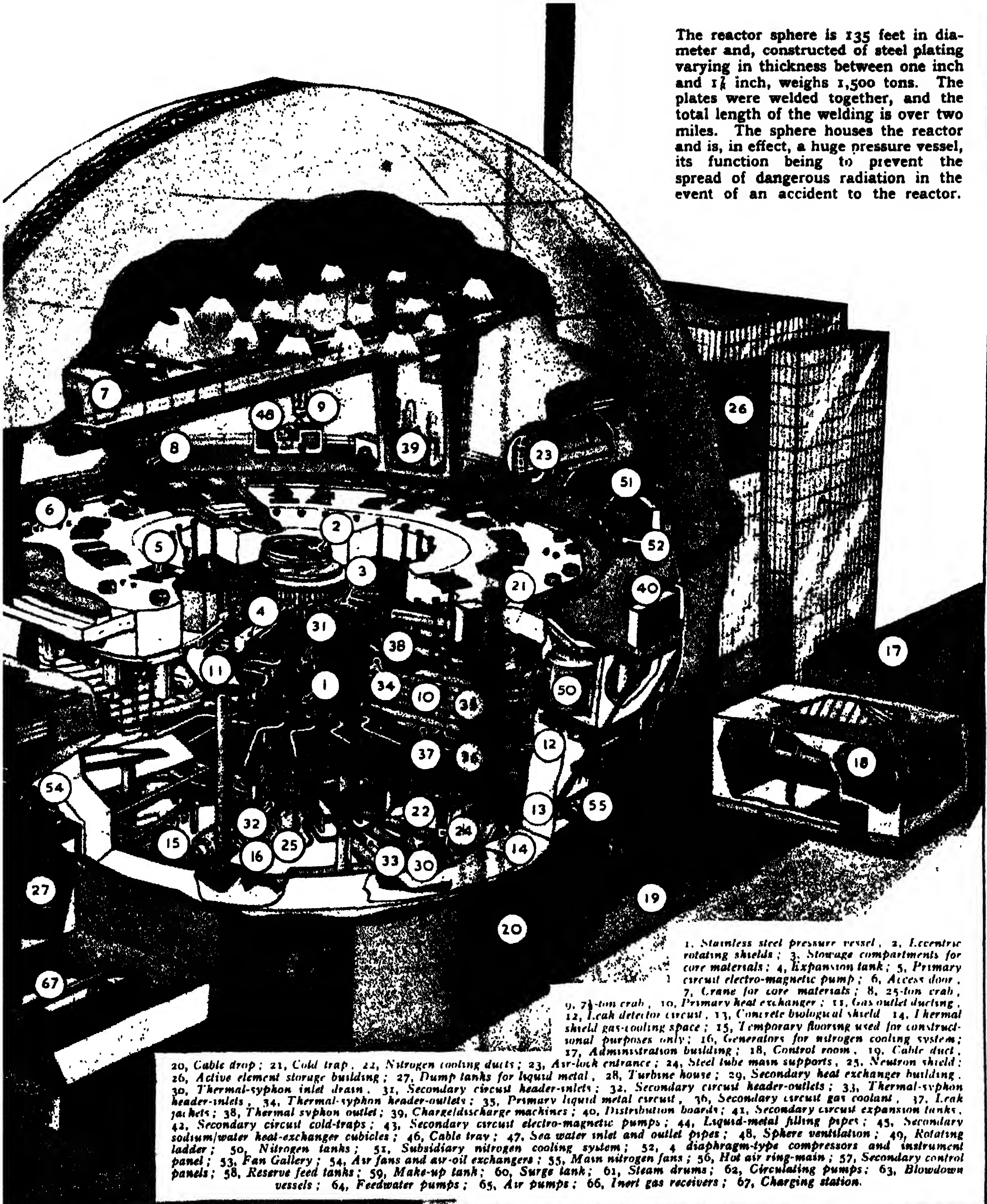
This photograph of the outside of the Atomic Research Station at Dounreay shows the reactor sphere with, on the left, the turbine hall, and on the right, the heat exchanger house.



Dounreay Atomic Research Station covers an area of 140 acres and, situated two miles from Thurso, Caithness, was formerly a Royal Navy aerodrome. The station cost £20,000,000 and, completed in 1958, took five years to build.

Although it is designed to generate electric power for domestic and industrial use in the north of Scotland, the Dounreay Atomic Research Station is primarily intended to gain information about what are called breeder reactors. A breeder reactor is a device which, during its production of atomic energy, produces more fissile material, or fuel, than it actually burns in its core. The source of power in the fast reactor at Dounreay, which is housed in the steel sphere, is the fission of uranium 235 and uranium 238 in the reactor core. Because the consequent fast neutron chain-reaction cannot be kept up in natural uranium 238, the fast reactor core contains a high proportion of uranium 235. The reactor core, which is 21 inches in diameter and 21 inches high, consists of uranium rods, sheathed in niobium containers and arranged vertically in a closely-packed bundle. Surrounding the reactor core is the breeder, called a blanket, which is made up from 2,000 rods of natural uranium, each rod being 8 feet long and 1¼ inches in diameter. The reactor core and the breeder

FUEL THAN IT USES TO GENERATE CURRENT

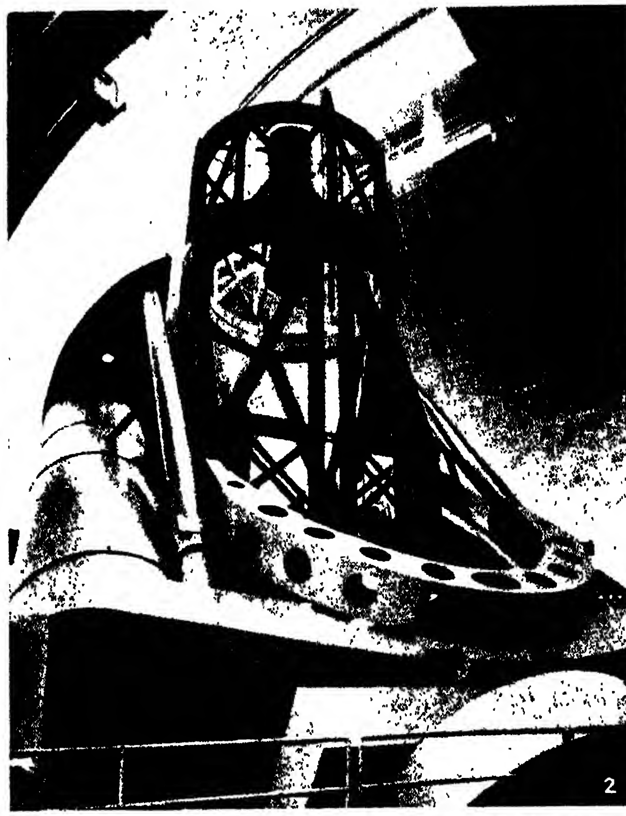


The reactor sphere is 135 feet in diameter and, constructed of steel plating varying in thickness between one inch and 1⅛ inch, weighs 1,500 tons. The plates were welded together, and the total length of the welding is over two miles. The sphere houses the reactor and is, in effect, a huge pressure vessel, its function being to prevent the spread of dangerous radiation in the event of an accident to the reactor.

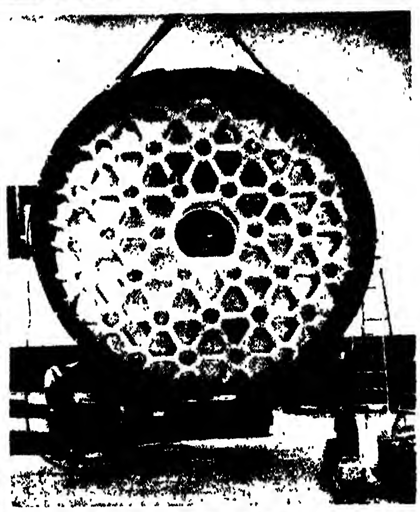
1, Stainless steel pressure vessel; 2, Eccentric rotating shields; 3, Stowage compartments for core materials; 4, Expansion tank; 5, Primary circuit electro-magnetic pump; 6, Access door; 7, Crane for core materials; 8, 25-ton crab; 9, 7½-ton crab; 10, Primary heat exchanger; 11, Gas outlet ducting; 12, Leak detector circuit; 13, Concrete biological shield; 14, Thermal shield gas-cooling space; 15, Temporary flooring used for constructional purposes only; 16, Generators for nitrogen cooling system; 17, Administration building; 18, Control room; 19, Cable duct; 20, Cable drop; 21, Cold trap; 22, Nitrogen cooling ducts; 23, Air-lock entrance; 24, Steel tube main supports; 25, Neutron shield; 26, Active element storage building; 27, Dump tanks for liquid metal; 28, Turbine house; 29, Secondary heat exchanger building; 30, Thermal-syphon inlet drain; 31, Secondary circuit header-inlets; 32, Secondary circuit header-outlets; 33, Thermal-syphon header-inlets; 34, Thermal-syphon header-outlets; 35, Primary liquid metal circuit; 36, Secondary circuit gas coolant; 37, Leak jackets; 38, Thermal syphon outlet; 39, Charge/discharge machines; 40, Distribution boards; 41, Secondary circuit expansion tanks; 42, Secondary circuit cold-traps; 43, Secondary circuit electro-magnetic pumps; 44, Liquid-metal filling pipes; 45, Secondary sodium/water heat-exchanger cubicles; 46, Cable tray; 47, Sea water inlet and outlet pipes; 48, Sphere ventilation; 49, Rotating ladder; 50, Nitrogen tanks; 51, Subsidiary nitrogen cooling system; 52, 4 diaphragm-type compressors and instrument panel; 53, Fan Gallery; 54, Air fans and air-oil exchangers; 55, Main nitrogen fans; 56, Hot air ring-main; 57, Secondary control panels; 58, Reserve feed tanks; 59, Make-up tank; 60, Surge tank; 61, Steam drums; 62, Circulating pumps; 63, Blowdown vessels; 64, Feedwater pumps; 65, Air pumps; 66, Inert gas receivers; 67, Charging station.

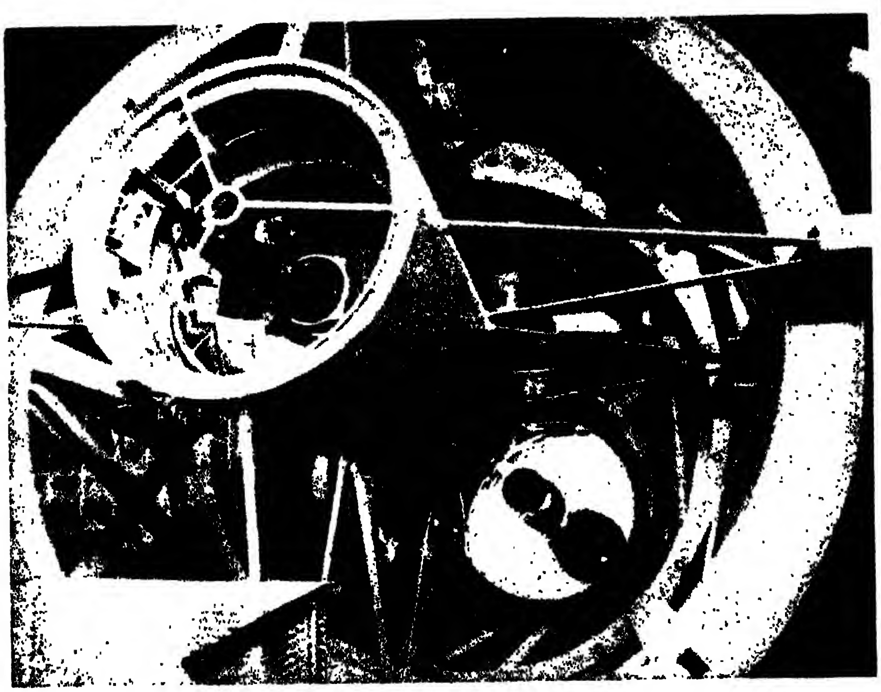
are contained in a stainless-steel "pot," called the reactor vessel, which is 10 feet 6 inches in diameter and 20 feet long. Liquid sodium-potassium is pumped into the top of the reactor vessel and flows over the reactor to keep it cool. As the cooling liquid passes from the vessel it carries with it the heat generated by the atomic fission of the materials in the reactor and transfers it to heat exchangers. There the heat is transferred to a liquid metal, which in turn heats water to produce steam. The steam is then used to drive the turbo-alternators which generate electric power. The whole operation is controlled from a room in the administration building. At the rear of the administration building is a heavily-shielded storage block where the atomic materials are kept until required. The enormous quantities of water needed for cooling the condensers and other equipment at the station are pumped from the sea coast, about 100 yards away. Half a mile from the station are the buildings where the engine for the Royal Navy's first atomic-powered submarine is being built.

TELESCOPE THAT SEES 1,000 MILLION LIGHT YEARS



These photographs give you some idea of the huge telescope at Mount Palomar, California, which since 1950 has been probing into space to a distance of 1,000 million light years, a light year is equal to 5,878,200 million miles. 1. *An audience of several hundred people listening to a lecture under the 140-ton tube of the telescope.* 2. *The balancing mechanism supporting the telescope tube.* 3. *The telescope's 200-inch mirror which weighs 14½ tons: the back of the mirror is honeycombed to reduce weight and to allow for temperature changes.* 4. *A technician adjusting the camera mounted in the tube of the telescope, the camera photographs star images reflected in the mirror.* 5 *The observatory building housing the telescope, which with its mountings and other equipment weighs nearly 1,000 tons.*





THE WONDERFUL STORY OF THE PEARL

The pearl is a very beautiful jewel, and yet its origin is very strange, and not such as we should associate with anything beautiful. It is found within the shell of the pearl oyster, but it is not a sign of good health, but of a complaint from which the oyster is suffering. Nevertheless, its story is a romance, as we shall see when we read here the history of the pearl and its formation

Of all the jewels worn by ladies, none is more beautiful than the pearl with its dainty texture and iridescent colour. Yet how many of those who wear pearls have any idea that these beautiful objects are the tombs of little worms?

Most of us are aware that the pearl is made by a creature known as the pearl oyster, though really it is not an oyster at all, but a mollusc that would be more correctly termed a mussel.

The pearl oyster, to give it its popular name, lives in a double or two-valved shell, the material of which consists of three layers. The outer layer is rough and hard, while the innermost layer consists of that beautiful substance which we call mother-of-pearl, but is known to men of science as nacre. The mollusc that lives in this shell is a soft creature which is wrapped in a mantle or flap of skin, and it is this mantle in contact with the shell everywhere, that makes the mother-of-pearl material.

A Lovely Substance

Exactly how the mollusc produces the substance is not known, but in some way it takes the mineral aragonite which is dissolved in sea-water, combines it with certain organic material and produces the lovely substance which forms both mother-of-pearl and the individual pearls which are worth so much. Aragonite, by the way, is the mineral which often forms layers on the inside of boilers that use hard water. From time to time the boilers have to be cleaned out by having this hard mineral substance chipped off the insides.

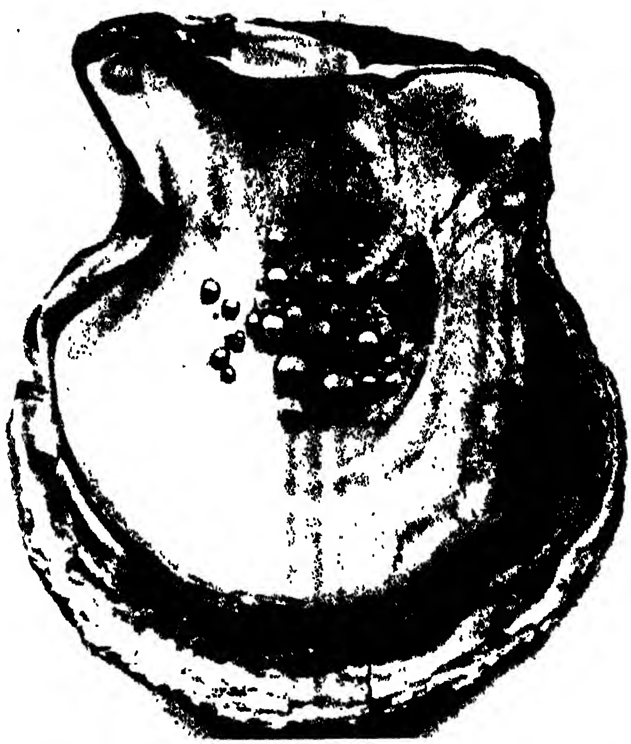
Whenever any foreign substance gets into the pearl oyster's shell, the creature is irritated and begins coating the intruder with mother-of-pearl. Knowing this, the Chinese open the shells and insert little leaden images of Buddha. The oyster at once begins to coat the figure with nacre, and after a time the shell is opened once more and the little pearl Buddha taken out.

In the same way the Japanese open a pearl oyster shell and pop inside a tiny grain of mother-of-pearl which they have rounded. The mollusc covers this with coat after coat of nacre, and in due course a pearl is produced which can be taken from the shell and sold. It has all the appearance of a real natural pearl which has been produced without any intervention on the part of man.

How are the genuine natural pearls produced? Well, here comes in the romantic story of the little worm. There are certain parasites which prey upon the pearl oyster, slipping in through the opening between the two valves. They irritate the oyster, which at once begins to coat them with nacre. Of course, when they are enclosed they die, and so the beautiful pearl on which layer after layer is added, becomes their tomb. It is pearls of this kind that are the real jewels which are so much sought after. Of course, even a grain of sand inserted in the oyster-shell will become coated, but it is the pearls caused by parasites that are so much in demand, and which are the genuine natural pearls.

When the pearl oyster begins to coat the parasite or any other object with nacre, the first layers correspond roughly to the outline of the embedded object, but gradually the later layers smooth over any irregularities and a perfect pearl is as spherical as a ball. Of course, the nearer to the shape of a sphere a pearl may be, the more valuable it is.

Sometimes the pearls are attached to the shell, and when they are taken away it can always be seen where they joined the mother-of-pearl lining. The most valuable pearls are those which are formed not on the shell but in the soft part of the mollusc.



A wonderful collection of pearls found inside the shell of an oyster that was brought up by the pearl fishers at Sharks Bay on the coast of Western Australia. The photograph was taken by Mr. W. Saville Kent who spent many years in the Australian pearl fisheries.

Pearls from Ceylon

Pearl oysters are found in different parts of the world, in the north of Australia, for example, but the most valuable pearl fisheries are those of Ceylon. The oysters are brought up from the sea-bed by natives who dive without any diving dress. These men are able to stay under water from 50 to 80 seconds at a time, and while they are there they rapidly scoop up the oysters, placing them in baskets slung round their necks. They start their work early in the morning, and by midday are exhausted and have to rest for the remainder of the day. The whole of the Ceylon pearl fishery is under the control of the Government, and the greatest precautions have to be taken to see that none of the pearls is stolen. On some days as many as 4,500,000 oysters are brought up from the sea-bed, and 41 millions have been taken in the course of 38 days.

It might be thought that with such captures the stock of pearl oysters would soon become exhausted, but the creatures multiply very rapidly, and when some years ago a Government inquiry into the state of the pearl fishery was carried out by scientists, it was found that the number of young

oysters at one place alone numbered over a hundred thousand million.

The pearl oyster, unlike the edible oyster of our own shores, which remains fixed for life, moves about from time to time. It fixes itself to a bank under the sea by means of the bundle of threads known as the byssus, a word meaning cotton, but when it wishes to migrate to another place it slips its natural cable and travels freely to the new feeding ground.

The pearl fishers dive from boats which go out some distance from the shore, and as the oysters are brought to the surface the men on the boats sorts them out, cleaning away the sea-weed, stones, and other objects which cluster round the shells.

When the boat has a full load it returns to the shore, and the oysters are carried to a Government building, a large shed, where they are divided into three heaps. Two belong to the Government and the third is the property of the divers, who share it among themselves. The Government's oysters are sold by auction in lots of one thousand, and some dealers buy as many as 50,000. The purchaser removes the shells to his own shed, where they remain in water for a week and decay. Then they are searched for the pearls.

At one time diving for pearls was by natives who worked naked, holding their breath while under the water, but nowadays most pearl collectors wear diving suits, and are thus able to spend more time selecting the pearls.

A Workman's Luck

Sometimes a pearl is so embedded in the nacre covering of the shell as to pass unnoticed, but it may be found later when the mother-of-pearl is being taken from the shell for the making of knife-handles and other articles.

Some years ago a Birmingham workman found a fine pearl the shape and size of a small damson, while cutting the mother-of-pearl from a shell, and it was sold for some hundreds of pounds.

A pearl taken from a shell less than four years old is of little value, and it is believed that after the age of seven the mollusc deteriorates as a pearl producer.

The pearl divers are subject to many dangers. One, of course, is the injury of their breathing organs owing to the constant holding of their breath for long periods, and another is the liability to attack by ground-sharks which abound in the seas round Ceylon. A diver makes as many as forty or fifty descents in the course of a day.

Of course, pearls vary greatly in size as well as in shape and quality The largest pearl ever found was about the size of a hen's egg, but great quantities are found not bigger than small shot. These are of little value.

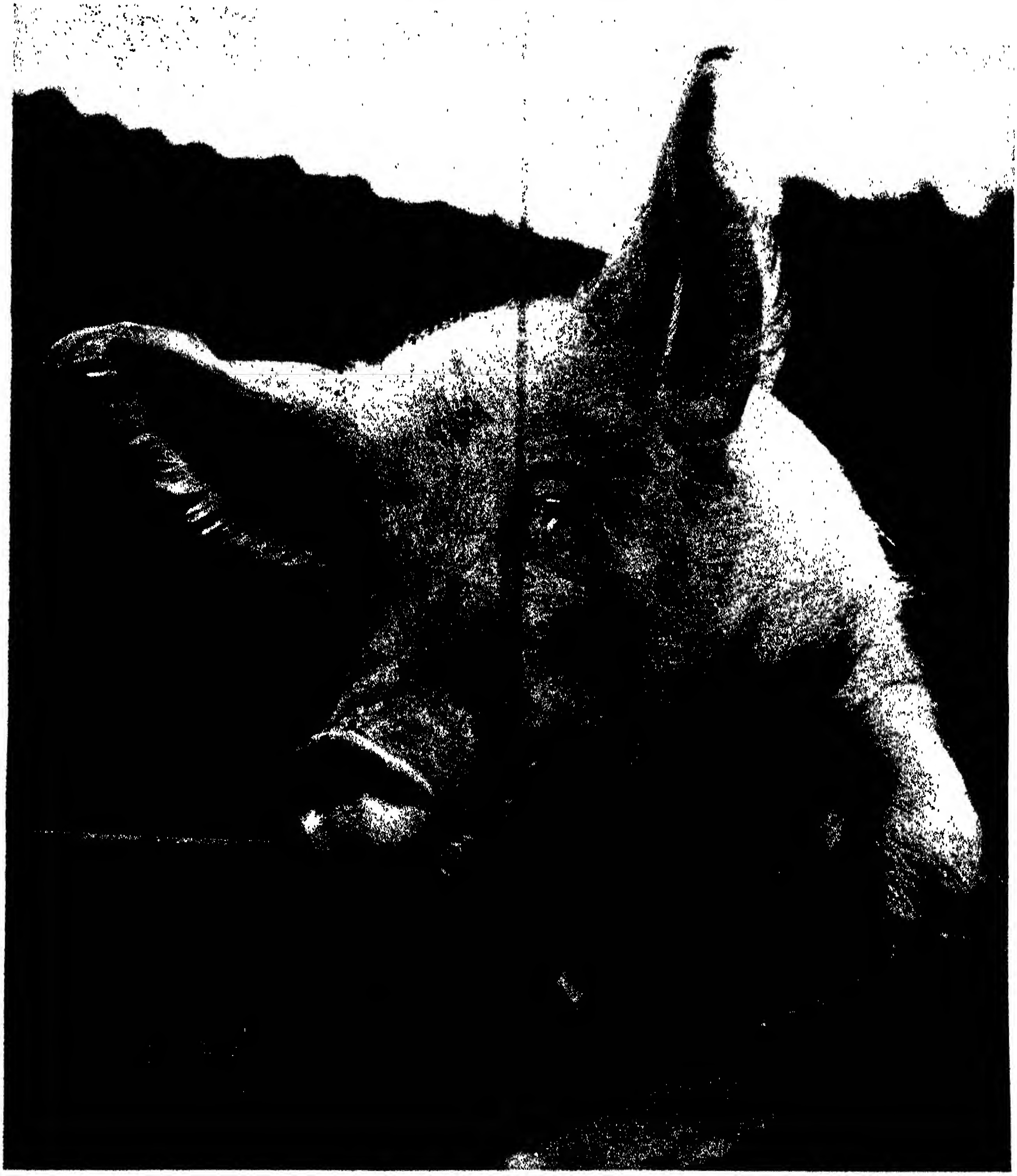
Pearls are also found in certain fresh-water mussels that live in European rivers, including the Forth, Tay, Doon, and other Scottish rivers. Indeed, in the Middle Ages Scotland was famous for its pearls, and rather more than a century ago as many as £10,000 worth were sent to London in the course of three years. But over-fishing ruined the industry. Even now, however, pearls are often found in river molluscs, and as much as £100 has been paid for a fine Scottish pearl.

The fresh-water pearls are formed in just the same way as those of the pearl oyster. A little larva makes its way inside the mollusc's shell, and sets up irritation which causes the mussel to coat the intruder with nacre

THE STRANGE BUTTRESSES OF THE PADDLE-WOOD TREE

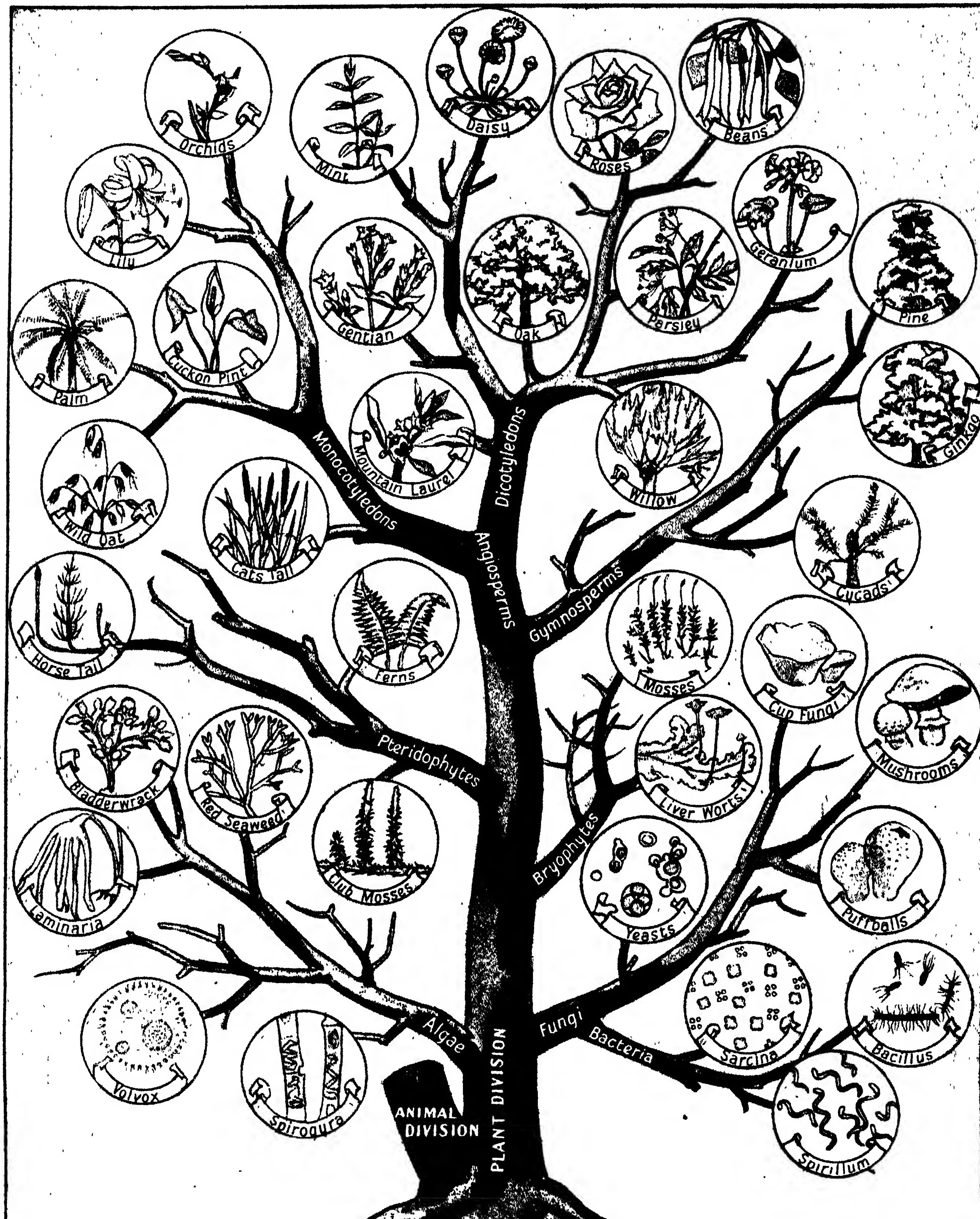
This photograph shows a very remarkable tree that grows in the forests of Guiana. The lower part of its trunk is surrounded by buttresses that give the tree a great strength in standing against winds and storms. One might almost think that this tree gave the architect his idea for buttresses to the towers of churches and cathedrals. It is really a striking instance of how man has been forestalled by Nature in a clever and useful device. These buttresses are cut down and used by the natives of Guiana as paddles for their canoes, hence the popular name of the tree. The timber of the paddle-wood tree is used for making the rollers of cotton-gins

WHY THE PIG HAS A LARGE FLAT SNOUT



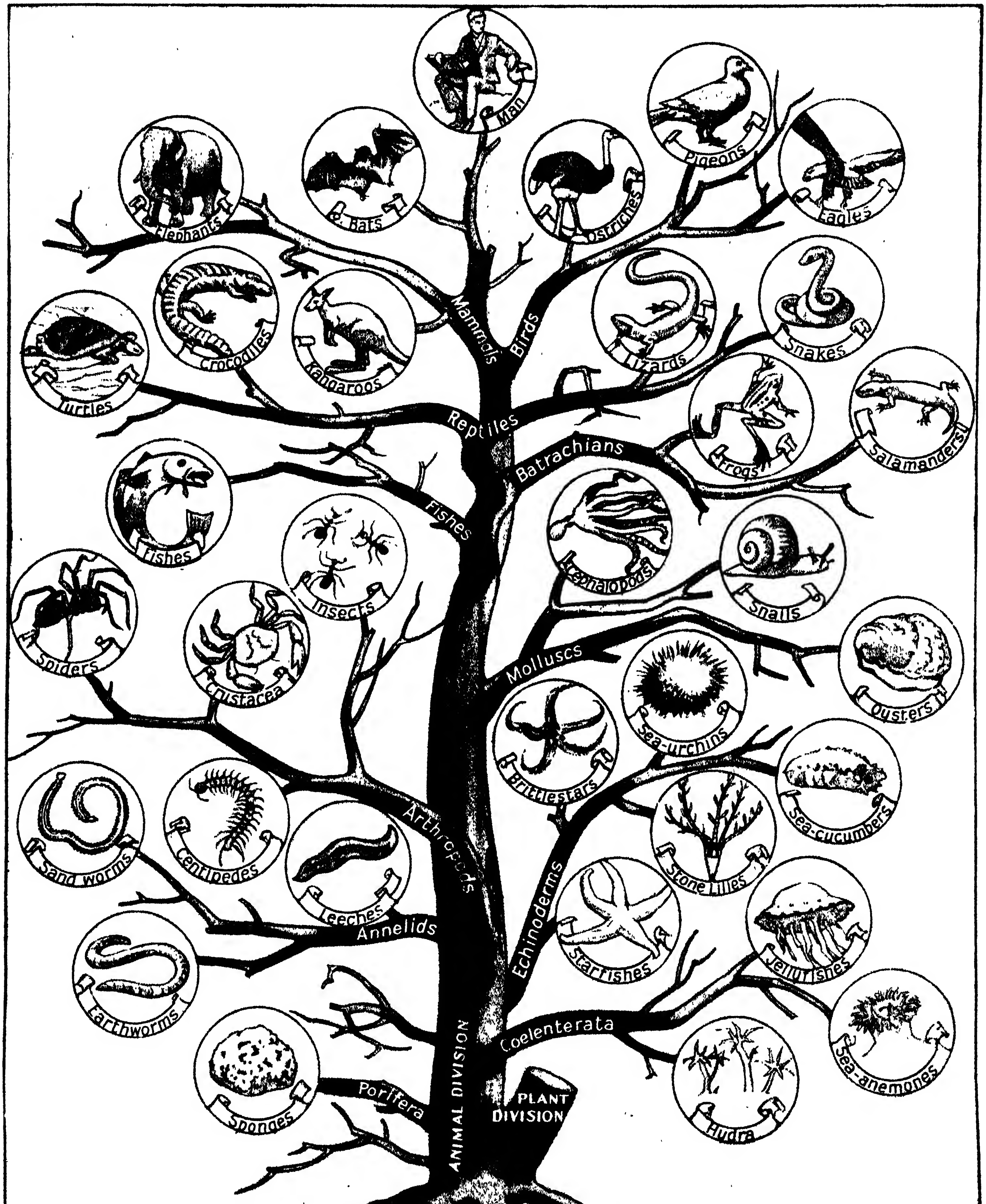
The pig, whether wild or domesticated, could never be mistaken for any other animal. Its long head ends in a wide, flat snout, which is very mobile and has in it the openings of the two nostrils. This snout, although consisting of a fleshy disc, is exceedingly tough, and is so constructed that with it the pig can plough up the earth and seek for roots, tubers and fungi, of which it is very fond. In order to give the snout digging strength the disc is supported by an additional separate bone at the extremity of the skull. Of course in the domesticated state the pig has no need to root about in the earth for food, as it does in the wild state; but in France pigs are trained to hunt for truffles, those much-sought-after edible fungi which are found growing under the surface of the ground. Contrary to the general opinion, the pig when kept as a pet is a perfectly clean animal, and it is also remarkably intelligent. Those who hunt the wild boar have a very great respect for its strategy when it is chased and trying to save its life. Pigs are easily trained and can be made to perform wonderful feats of counting, selecting cards, and so on. The pig has even been taught to act the part of a dog in bird shooting, and is said sometimes to excel the pointer in " pointing." This picture shows an inquisitive boar at a piggery in Essex

THE MANY-BRANCHED TREE OF PLANT LIFE



Men of science look upon life as a great tree with two main stems, each springing from the same root. One stem is that on which are found the various branches of vegetable life. The main divisions are shown here with some of the smaller branches that spring from these.. As one travels up the stem one comes to higher forms of plant life like flowering plants that developed later in time than some of the lower forms like fungi and seaweeds. Many branches of the great plant stem of the tree of life have perished in the course of time and are no longer to be found except among the fossils embedded in the rocks that were formed in far distant ages

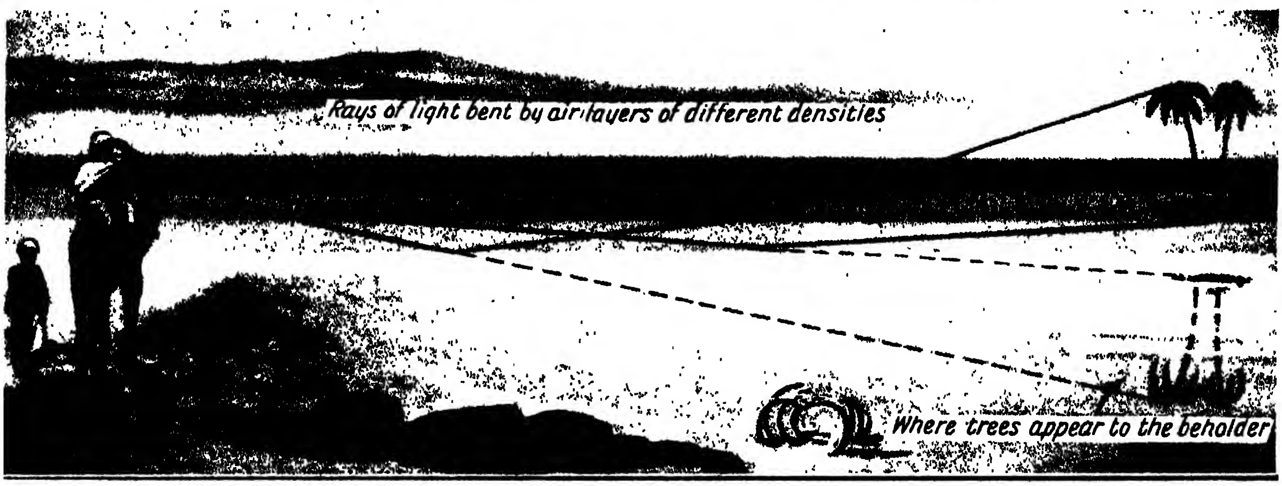
THE WONDERFUL TREE OF ANIMAL LIFE



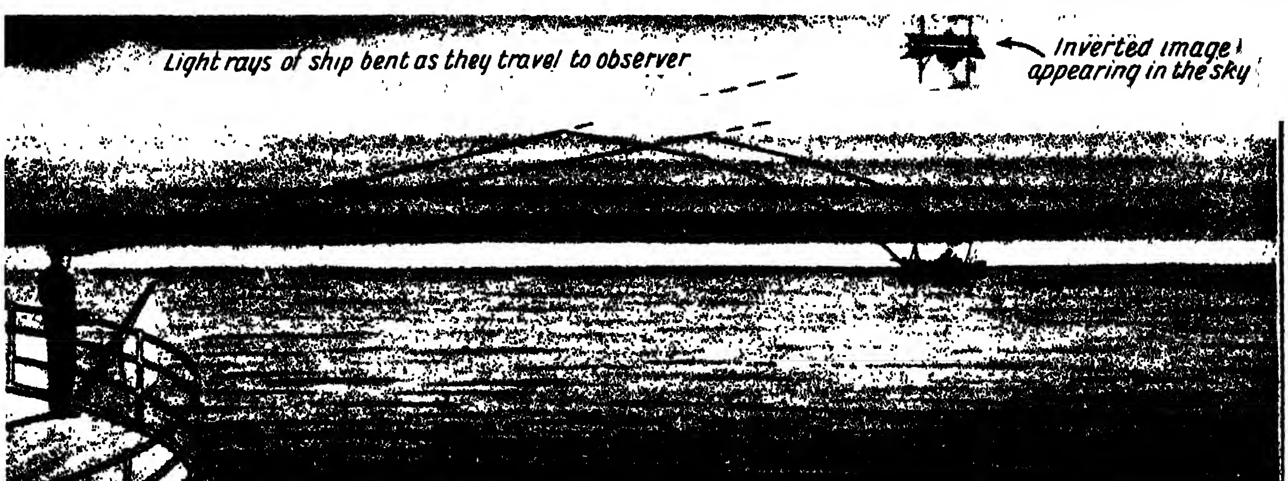
Early in its history, men of science tell us, the great tree of life divided into two main stems and while one branched out into varied forms of plant life, the other, as shown here in diagram form, produced many branches of animal life. Far back in time the animals were of a simple and lowly form, but as we can see when we look at the picture, ever higher forms of animal life appeared till at last came the great branch of the mammals with its crowning development called Man. Whatever way we look at life, there is a kinship between ourselves and all other living creatures. The Bible refers to this by describing all life as emanating from the one great Creator

HOW THE MIRAGE OF THE DESERT IS CAUSED

Travellers in the desert are sometimes attracted by what appears to be an oasis in the distance with abundant water and palm trees. They hurry forward, but as they travel the oasis recedes, and they fail to reach it, for it is a mirage, that is, an illusion, not being where it is seen The word "mirage" is from a Latin verb, meaning "to wonder at." Below we see how the mirage is caused



Here we see what happens when the traveller sees a mirage. The trees really exist, but not where they are seen. They are in some more distant place, and the rays of light from them pass through various layers of air which are at different temperatures, those near the hot sand being warmest and least dense. The result is that these rays of light are refracted or bent, the trees and other objects appearing nearer with inverted images. The rays cross and reach the traveller's eye as shown, and he thinks they have come from the direction of the dotted lines and therefore fancies he sees trees and reflections in water. Sometimes these mirages are very vivid indeed



A phenomenon like the mirage is sometimes seen by mariners at sea They observe in the air inverted images of ships. In this case the air in contact with the water is colder and denser than that above, and so the rays are bent in a different direction from those in the desert The seaman fancies he sees the inverted ship in the sky. The eye always imagines that bent rays come in a straight line

THE GREAT MYSTERY OF THE MIRAGE

The mirage is a very curious and mysterious natural phenomenon. It is generally seen in the desert, but it can also be seen sometimes in London in such thoroughfares as the Mall, and it can be produced in a laboratory by means of a simple apparatus shown in the picture below. As we read on this page, the scene that appears in a mirage has always some reality a great distance away

A MIRAGE is a curious optical illusion most commonly witnessed in hot dry desert countries, although an appearance very similar to it is also noticed from time to time in the Arctic and in mountainous regions.

The form which the desert mirage takes is that shown in the pictures on the previous page. Tired and thirsty travellers suddenly see before them at no great distance palm trees with what appears a refreshing sheet of water. They hurry forward, but the oasis seems to recede as they travel.

The explanation is that the sun-heated sand warms the layer of air in contact with it, so that this is of a different density from the air still higher. There may indeed be several layers of air of different densities, and the rays of light from a distant grove of palm trees are bent so as to bring the trees in appearance much nearer than they really are.

The rays of light from different parts of the palm trees also cross one another so that the trees are seen in an inverted form, which gives the impression of a reflection in water.

Livingstone tells us how when travelling in the Kalahari Desert he saw the mirage of a lake which was 300 miles distant from where he was. "Here," he says, "not a particle of imagination was necessary for realising the exact picture of large collections of water; the waves danced along above, and the shadows of the trees were vividly reflected beneath the surface in such an admirable manner that the loose cattle, whose thirst had not been slaked sufficiently by the very brackish water of Nchokotsa, with the horses, dogs, and even the Hottentots, ran off towards the deceitful pools.

"A herd of zebra in the mirage looked so exactly like elephants that Oswell began to saddle a horse in order to hunt them; but a sort of break in the haze dispelled the illusion."

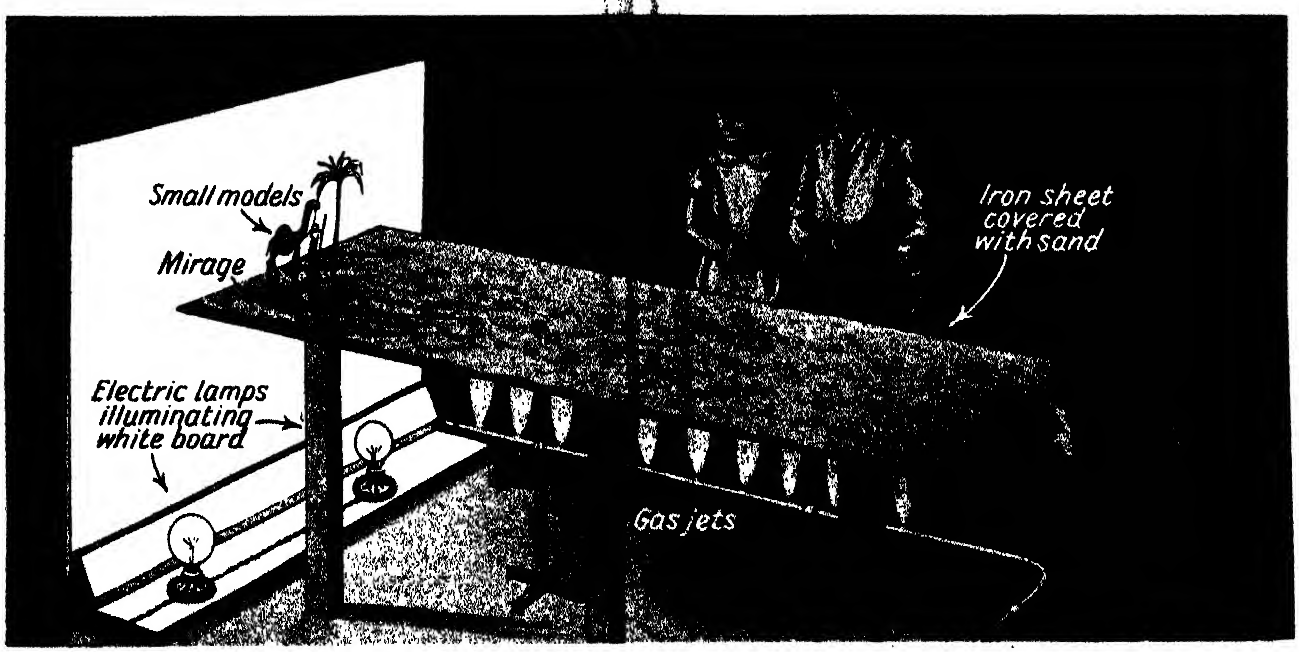
It seems amazing that the scenery could have been thrown over the curvature of the Earth for such a great distance as 300 miles, and it is interesting that the animals recognised the mirage.

The looming or appearance of ships high up in the sky which is seen from time to time in the Arctic is a form of mirage, and the mirage seen occasionally in the Alps has been described by Lt.-Col. P. Neame.

"Mr. F. S. Smythe and I," he says, "were climbing the Finsteraarhorn in the Bernese Oberland on May 2, a day of perfect weather and extremely good visibility. When on the rock ridge within 300 or 400 feet of the summit, that is, at an altitude of about 13,800 feet, we paused to admire the very fine panorama of mountains all round us. We could clearly identify the Black Forest some 150 miles to the north, and we saw snow-capped peaks in Italy certainly 100 miles or more to the south. All the giants of the Alps, Mont Blanc, Weisshorn, Matterhorn, Monte Rosa, etc., although some were thirty and forty miles away, stood out as if across the next valley. . . .

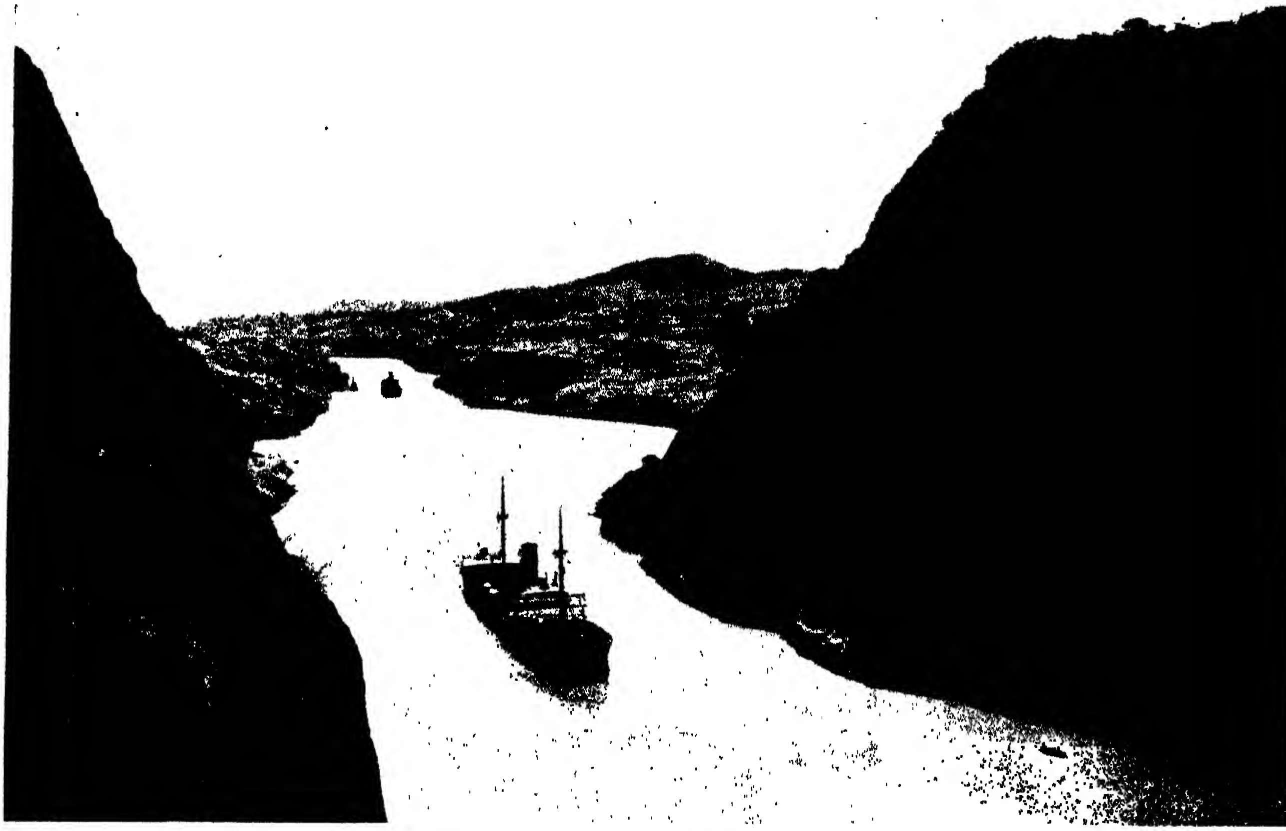
"Suddenly at 11.55 a.m. the image of a ship appeared in the sky just to the east of the Eiger peak, floating in a blue shimmer just beyond the visible horizon. This lasted for a minute or so, and then vanished.

"Very soon after a line of five ships appeared farther east, funnels and masts clearly distinguishable. This image lasted for some fifteen minutes, and varied in its clearness from time to time. The ships appeared, of course, greatly exaggerated in size, and were right way up, not inverted." The nearest sea was the eastern exit of the English Channel into the North Sea, a distance of some 400 miles.

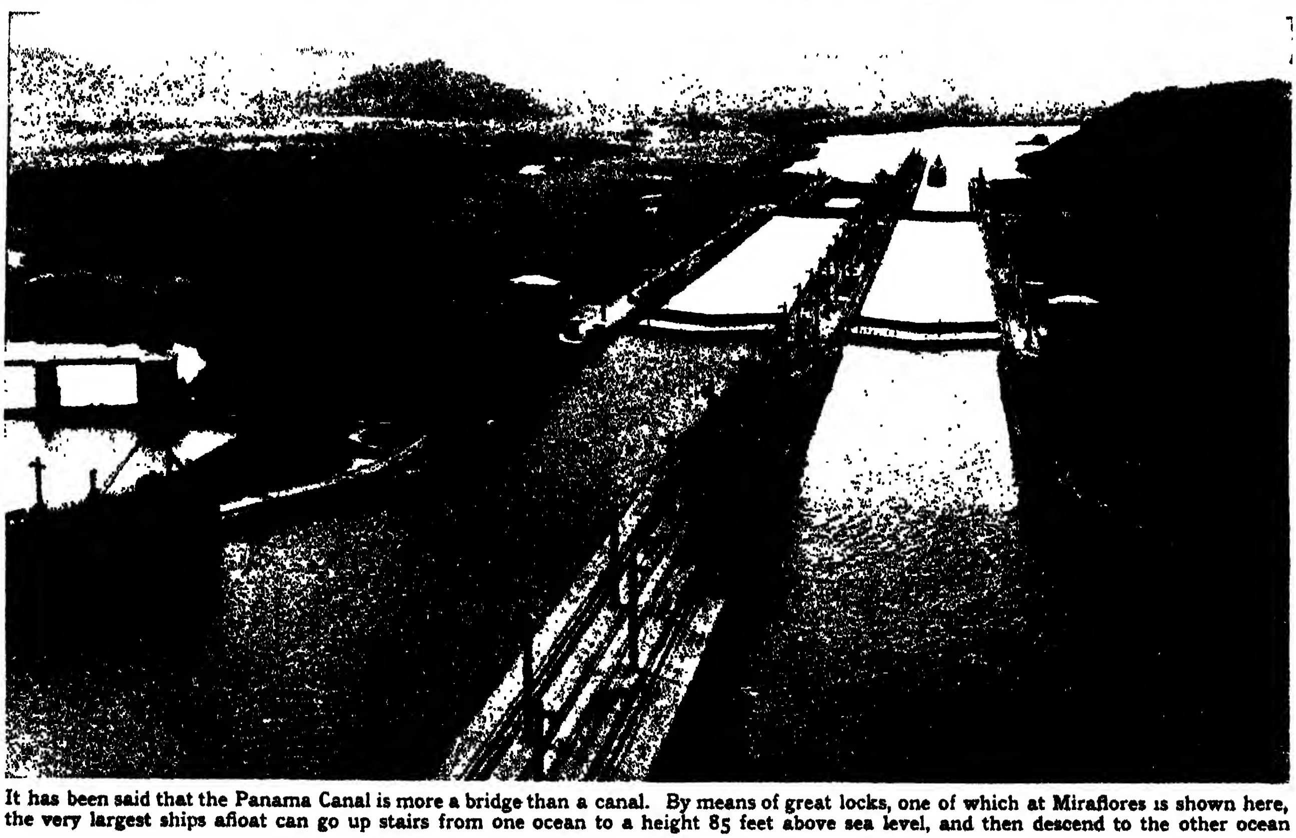


This picture shows how an artificial mirage is produced in a laboratory. A sheet of iron has spread on it a thin layer of sand. Underneath are burning jets of gas, which heat the iron and the sand. At the end of the surface is a vertical white screen which is illuminated by electric lamps below. Some models of objects are placed on the sand-covered surface near this screen, and the observer looking along the sand sees what appears to be water with the reflection of the objects in it.

A BRIDGE FOR SHIPS ACROSS A CONTINENT



The Panama Canal is the greatest engineering feat that man has ever undertaken. The French began the work and then the Americans took ten years to make the Canal. About 240,000,000 cubic yards, or 480 million tons, of material were excavated. Part of a mountain was removed and with the material two great dams were built to form a lake. Here we see the Canal cut through the Culebra Mountain



It has been said that the Panama Canal is more a bridge than a canal. By means of great locks, one of which at Miraflores is shown here, the very largest ships afloat can go up stairs from one ocean to a height 85 feet above sea level, and then descend to the other ocean

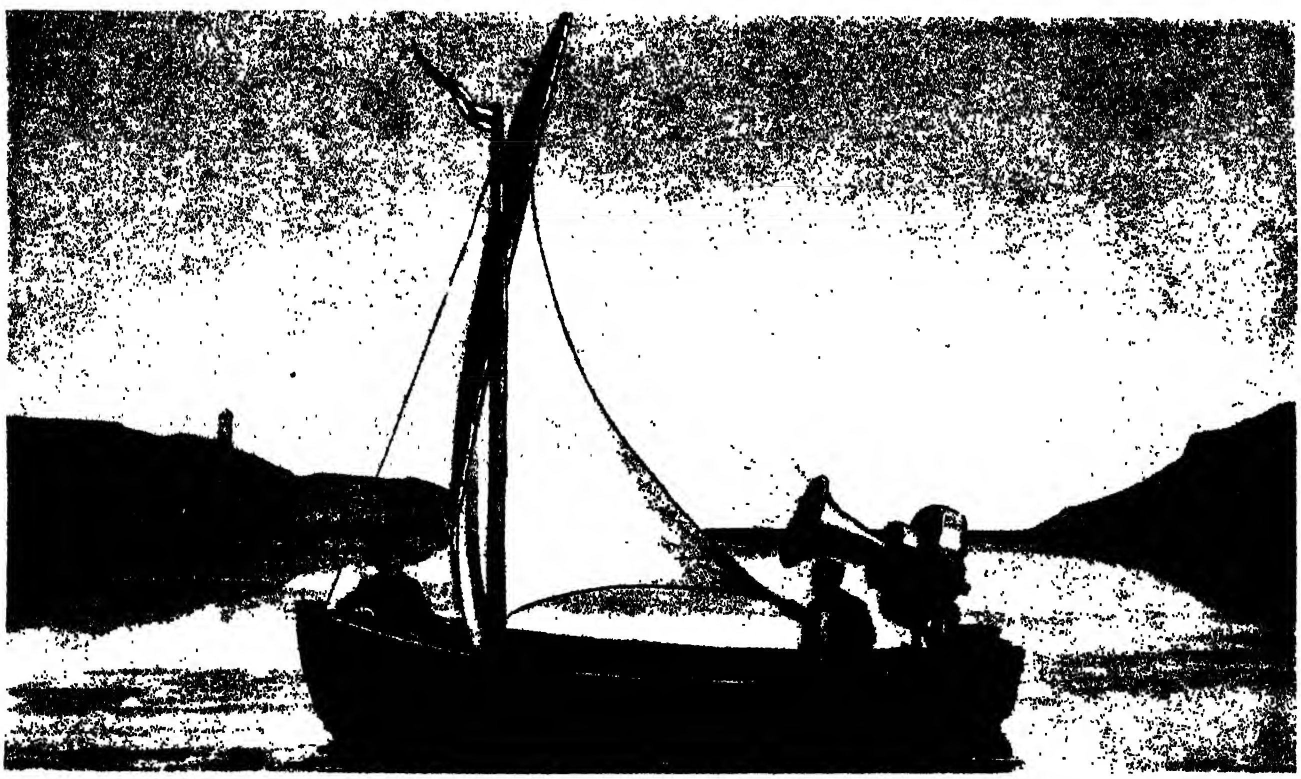
EARTH PILLARS & HOW THEY ARE FORMED

The left-hand photograph shows a curious geological formation known as an earth pillar. This particular one is in the Jasper National Park in Canada, but similar pillars are found in other parts of the world, as for example in the Tyrol, where there are many clustered together. How these curious pillars are formed is explained below. An earth pillar of this kind is quite different from such pillars as that shown in the right-hand photograph, which represents the Devil's Chimney at Cheltenham, a well-known landmark in Gloucestershire. In this case the pillar was formed by the cracking and weathering of the rock which formed part of a steep cliff. The rock has gradually crumbled and fallen till only this pillar is left standing on the edge of a precipice

These pictures give successive stages in the history of earth pillars. Thousands of years ago hard blocks of stone were carried down by a river and deposited with other material so that they formed part of a layer of soft rock as in the first picture. Later the river bed was raised. Then rain pouring down wore away the softer rock as in the second picture. The blocks of harder rock protected the softer material underneath and at last they were left high and dry perched on pillars of the softer rock as in the third picture

WHY ONE BOAT MOVES AND THE OTHER DOES NOT

If we place a boat on the water in a bath and blow with our mouths or the bellows on the sail the boat moves. The pressure of the air directed against the sail pushes it forward in exactly the same way as if we press our finger against the sail. By this simple experiment, we see how it is that a sailing ship on the sea is made to travel by the winds that blow over the surface of the water



Here is a large boat on a river or sea with an apparatus on board that blows a strong current of air into the sail. But although the sail is puffed out the boat remains stationary. Why does it not move like the small boat above? Every action has an equal and opposite reaction The wind blows on the sail with a certain force, and there is a reaction in the opposite direction of the same force. In the upper boat this does not matter, as the reaction acts outside the boat; but in the case of the lower boat, the force being on the boat itself, the reaction is also on the boat and so the two forces neutralise one another and the boat remains stationary

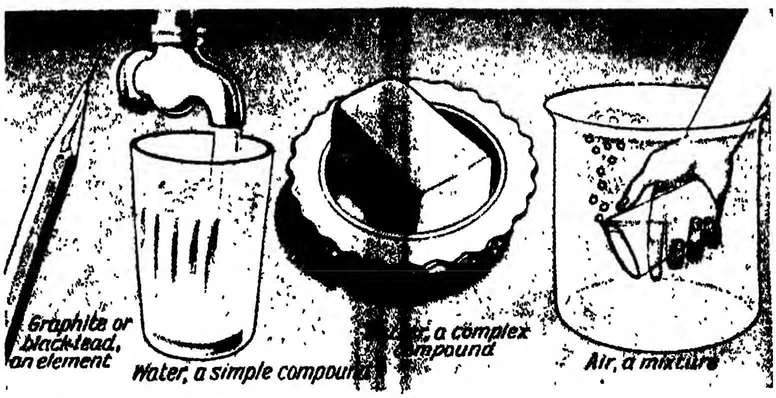
ELEMENTS THAT MAKE UP OUR WORLD

Look around you and you can count dozens, even hundreds, of things made from different materials; brick walls, wooden tables, glass windows, paper books, water in a tumbler, a grass lawn, a tree, coal in the fire, the wire in an electric light bulb, the rubber tyres of a bicycle, the ground under your feet, the flowers in a garden, the sun overhead and even your body. It has been estimated that there are over a million different materials in the world; yet every one of these materials consists of one or more elements, of which there are fewer than 100 different kinds in existence.

The joining together, or combining, of elements forms the innumerable compounds and combinations which make up the countless number of things we find in the world.

Long before man appeared on earth nature had been at work combining elements to form water, air, soils, plants, ores, and the vast universe of which the world is a tiny part. Then came Man, and as he progressed from ignorance to knowledge he learned how to combine elements himself and became a chemist. Some of the substances produced by chemists juggling with elements copy natural materials. Nylon and synthetic rubber, for example, do not exist in nature, but are made by chemists combining various elements.

An element may be a solid, a liquid or a gas. One of the commonest gas elements is oxygen, because it forms part of the air we breathe. Eleven of the elements are gases, two (mercury and bromine) are liquids, and all the rest are solids.



Here are four familiar types of common substances. Graphite or blacklead used in pencils is the element carbon. Water is a simple compound made up of the two elements oxygen and hydrogen. Butter is a very complex compound, containing many elements. And air is a mixture of the elements oxygen and nitrogen, with traces of one or two other gases.

All elements are made up of very small particles called atoms. Just as a wall is built up from hundreds of individual bricks, so a piece of copper, a lump of iron, a whiff of oxygen or a quantity of bromine consists of countless numbers of atomic particles. Moreover, the atoms of any particular element are always quite different from the atoms of any other element; thus, an atom of the element iron has its own peculiarities and cannot be confused with, for example, the atoms of the element hydrogen.

It is by combining together different kinds of elements and their atoms that we get what are called compounds. For example, water is a compound because it is made up of two atoms of hydrogen and one atom of oxygen.

When a mixture of elements such as water is divided and divided until it becomes the smallest possible quantity of water still containing atoms of all the elements that make up water it is called a molecule. A molecule may consist of one or more atoms of different kinds of elements. The smallest possible speck or molecule of water still contains two atoms of hydrogen and one atom of oxygen; that is, it is still a compound.

Any substance whose molecules are composed entirely of atoms of the same kind is an element. Thus you can keep on dividing a speck of pure iron until it is invisible under the most powerful microscope and you will still have only one kind of atom; the atom of the element iron. As explained in the article beginning on page 1125, atoms of the various chemical elements are themselves made up of particles called electrons, protons and neutrons. It is the number and arrangements of these particles that makes all the atoms of one particular element the same, just as it makes the atoms of one element different from those of another element. In other words, the elements are different from each other because the number and arrangements of their atomic particles are different.

Chemists refer to elements by their atomic numbers and weights. Atomic weight is the sum of the neutrons and protons in an element, while the atomic number is the number of electrons in the element's atom. The copper atom, for example, has 29 protons and 35 neutrons, these added together make 64, which is the atomic weight of the copper element. The copper atom has 29 electrons, so that the atomic number of a copper element is 29.

The atomic numbers of elements begin with 1 for hydrogen, as the atom of the element hydrogen has only one electron. Then comes the element helium, the atomic number of which is 2, because it has two electrons; the element lithium, atomic number 3, which has three electrons; the element iron, with 26 electrons and therefore the atomic number 26; and so on up to the element uranium, which because it has 92 electrons is given the atomic number 92.

Seven of the elements were known to the ancients, fifteen more were discovered by alchemists in the Middle Ages, while the others have been discovered by chemists of the nineteenth and twentieth centuries. It is customary to give newly-found metallic elements names ending in *ium*; such as chromium, sodium, calcium and magnesium.

Some of the names chosen for elements tell us the source of the element; *e.g.* potassium, which was first obtained from potash. Other elements get their names from some striking feature; *e.g.* iodine, which comes from a Greek word meaning violet, the colour of iodine when it is turned into a gas or vapour. Other elements have been named in honour of the discoverer's nationality. When Madame Curie discovered the element polonium she gave it that name because she was born in Poland.

Chemists usually refer to elements by abbreviations, particularly when writing about them as compounds. Water, for example, is written H_2O, because it is a compound of two elements of hydrogen and one of oxygen.

Some element symbols are single letters of the alphabet, generally the first letter of the name of the element. For example, C is the abbreviation for carbon, H for hydrogen, and O for oxygen. As there are more elements than letters of the alphabet, some elements are represented by two-letter abbreviations; among these are Cl for chlorine, Ca for calcium, and Cr for chromium.

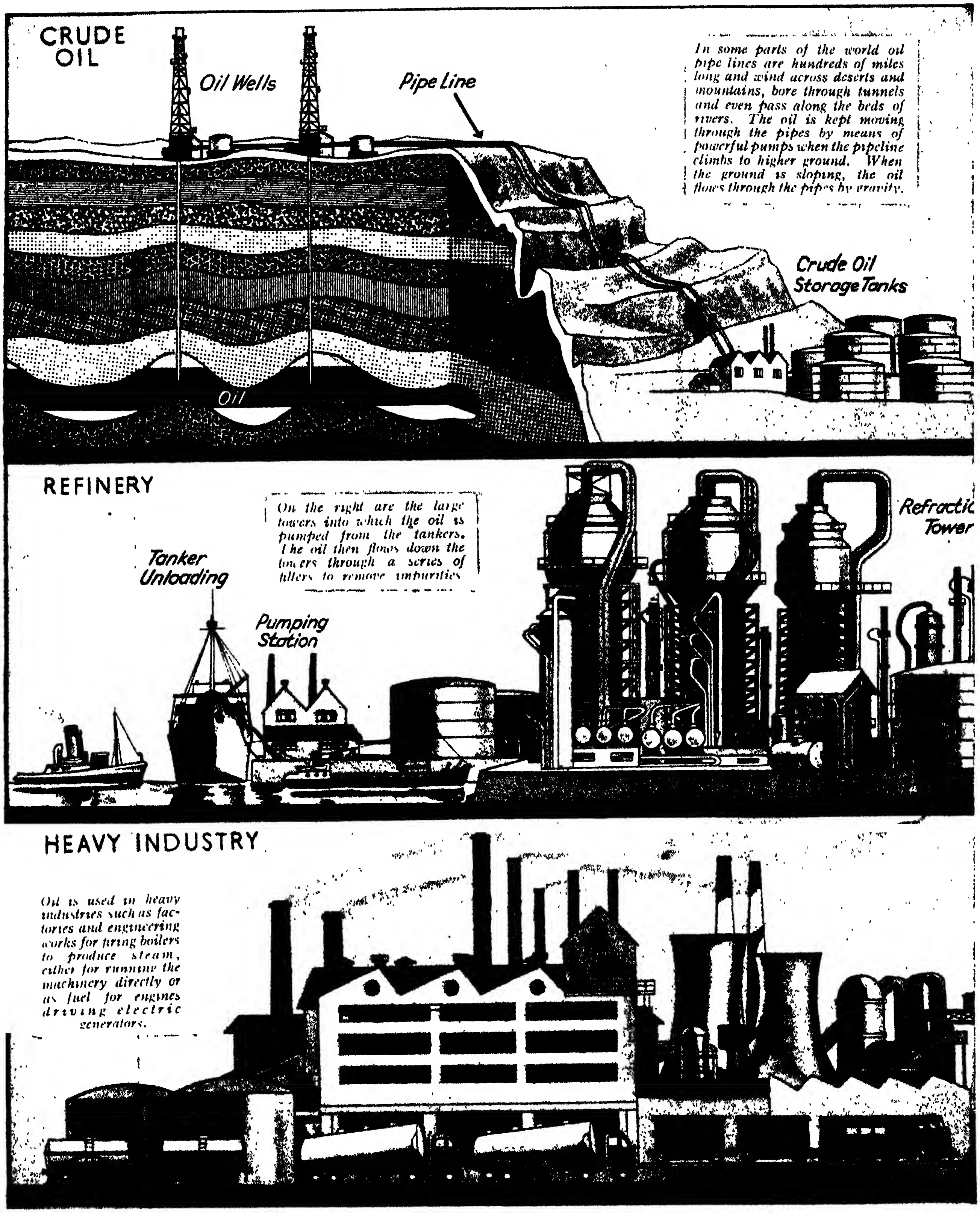
Very few elements are found in nature in the free or native state. Nature generally combines them with other elements to form compounds.

One of the most remarkable things about compounds of elements is that the new substance has properties entirely different from the elements forming it.

Consider, for example, the salt you sprinkle on your food. It is a compound of sodium, a dangerous metal which flares up and burns on contact with water, and chlorine, a highly poisonous gas; yet when combined these elements form harmless table salt.

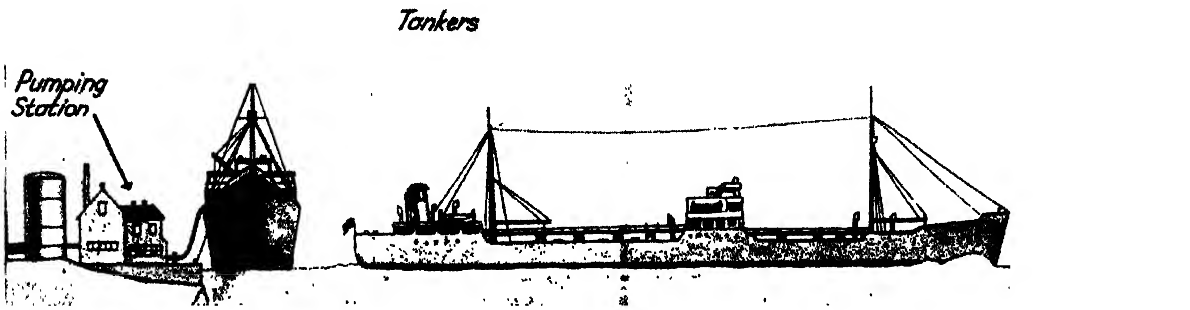
Without water we could not live; nevertheless water is a compound of two gases: hydrogen which burns, and oxygen which supports combustion.

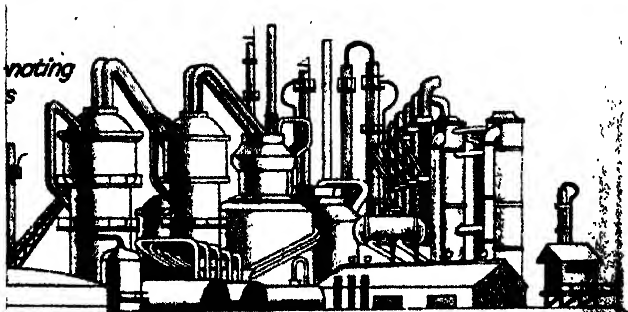
THE COMPLETE STORY OF BRITAIN'S OIL FROM



Nineteenth century industry and transport depended upon coal, and although coal is still the most used fuel as a source of power, oil is now the chief fuel for road and sea transport, while increasing numbers of diesel-electric engines are going into service on the railways and much industrial machinery is powered by oil or petrol engines. Indeed, without oil there would be no internal-combustion engine, and without the internal-combustion there would be neither aeroplanes nor motor traffic on the roads. Apart from comparatively small quantities obtained by the distillation of coal, the oil used in Britain has to be imported from places as far distant as Arabia, Burma and South America. Like coal, oil was formed deep down in the

Ships used for transporting oil are specially built for the purpose. As an oil cargo is highly inflammable, the engines and the crew's living quarters are at the stern and are separated by thick steel bulkheads (walls) from the rest of the ship. The holds or storage places for the oil are not like the holds on ordinary cargo vessels, but consist of long lengths of large-diameter piping arranged in banks between the after and forward bulkheads. This is to stop the oil moving in a heavy sea; if the oil was just poured into big holds it would surge from side to side and in rough weather capsize the ship. Arranged along the top deck are sprays through which water can be poured over the tops of the holds in very hot weather. This is necessary to prevent the heat of the sun from making the deck plating so hot that it would explode the oil. Some of the larger tankers can carry as much as 20,000 tons of oil at a time and steam at a speed of 18 knots



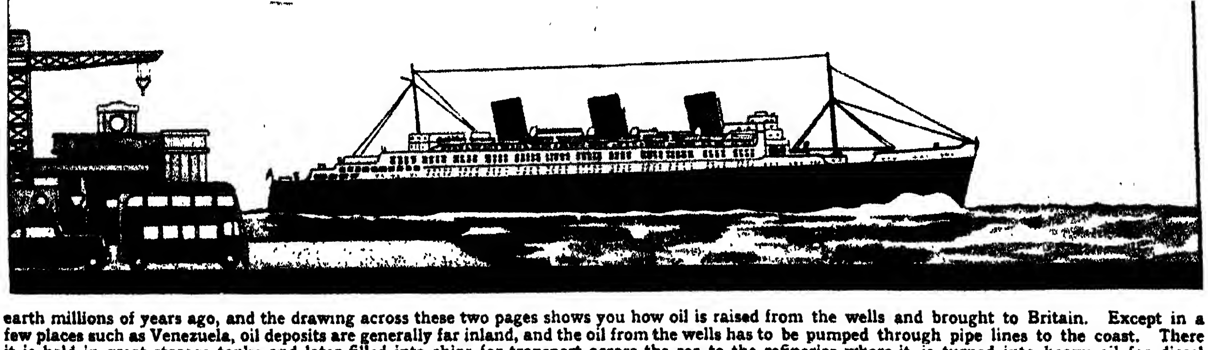


The refractionating part of an oil refinery is very like the collection of test tubes and globes in a chemist's laboratory, only on an enormous scale. At Fawley in Hampshire there is the largest oil refinery in England. It covers hundreds of acres of ground and handles millions of tons of oil a year. As the oil passes through the maze of pipes and retorts it is subjected to carefully-controlled heat and other treatment which separate the petrol from the oil and then divides these into different grades and qualities to suit different kinds of engines

TRANSPORT AVIATION SHIPPING

An airliner needs about ten tons of petrol to fly from London to New York. Each of the 7,500 buses in London uses an average of 50 gallons of diesel oil daily.

Some idea of the enormous quantities of oil used to-day can be gained from the fact that a ship like the Queen Elizabeth or the Queen Mary burns 4,000 tons to make a single voyage across the Atlantic.



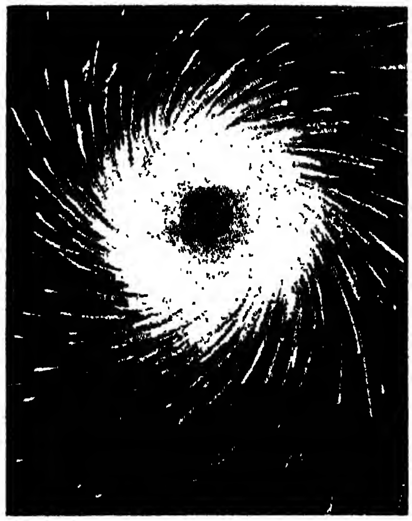
earth millions of years ago, and the drawing across these two pages shows you how oil is raised from the wells and brought to Britain. Except in a few places such as Venezuela, oil deposits are generally far inland, and the oil from the wells has to be pumped through pipe lines to the coast. There it is held in great storage tanks and later filled into ships for transport across the sea to the refineries where it is turned into heavy oil for diesel engines, petrol for motor-cars, paraffin for jet engines, and lubricating oil to reduce friction in the moving parts of machinery. From the refinery, the various kinds of oil are pumped into railway and road tankers for delivery to all parts of the country.

EXPERIMENTS SHOWING ACTION AND REACTION

Every action has a reaction equal and opposite to the action. We see this clearly in rowing The oars push the water backward and the reaction pushes the boat forward. We see it also in the kick of a rifle. The bullet is shot out in one direction and the rifle is shot back in the other direction. But in many cases we do not see the reaction For instance, when we run or jump we press our feet against the earth with a jerk, and this pushes our bodies up, but it is equally true that our feet push the earth down.

The action of pushing on the table results in a reaction, sending the chair and the boy in the opposite direction

On this page are some simple experiments that illustrate action and reaction. When we want to move our chair away from the table we push our hands against the table, and the reaction pushes the chair back. A girl skipping pushes her feet against the earth, and the reaction throws her body up in the air. Let us stand on the platform of a weighing machine and wait till the hand on the dial is still. Now, if we raise our arms upward we see the dial hand go round farther, for when we raised our arms upward the reaction pressed our body downward and gave a little extra push to the platform.



When the Catherine Wheel is lighted the rush of gas and sparks in one direction whirls the wheel round in the other direction

Go to the horizontal bar and pull yourself up by your hands. As you pull down on the bar, the reaction lifts your body up and the extent to which you are raised depends upon the force with which you pull down.

Sit in an ordinary garden swing and try to swing yourself You move your body forward and throw your legs back. But nothing happens. The reason is that your action forward results in an equal reaction in the other direction, and you remain still.

This boy cannot swing himself because his action forward has an equal reaction in the opposite direction

In the first picture the boy pulling down on the horizontal bar causes a reaction that lifts his body upward. In the middle picture the girl jumps up through the reaction of pressing her feet down on the earth. In the third picture the boy on the weighing machine presses the platform down still farther by reaction when he lifts his arm upward

THE GREATEST TRIAL IN ENGLISH HISTORY

Warren Hastings was one of the greatest of our Empire builders, but like many others who have enriched the nation at home he was shamefully treated when his great work in India was completed, and on returning he was deprived of those rewards and honours which should undoubtedly have been his. Here is his life-story

THE British people have never been conspicuous for gratitude to their great men. Warriors, successful and unsuccessful, have generally received more than their fair share of reward and honours, but in other spheres, such as invention and exploration and empire building the rewards have been meagre or absent altogether. In some cases base ingratitude has been the only recompense that a great man has received.

There is no more notable case of this than that of Warren Hastings, the first Governor-General of India. If Clive won the Indian Empire for Great Britain, it was Hastings who consolidated it and put its government on a firm and solid basis. Yet after many years of arduous toil, when he returned home he received the basest abuse, was treacherously left to his enemies by the rulers of the country—including the younger Pitt, who is said to have been jealous of him—and was put on his trial for "high crimes and misdemeanours." The trial lasted many years, almost ruined Hastings, and though he was acquitted, he was still deprived of those honours and rewards which should undoubtedly have been conferred upon him by the English Government.

An Unpromising Childhood

Warren Hastings had a not very promising childhood, nor can it have been very happy. He was the son of a rather improvident clergyman who had married at the age of fifteen, and a few days after Warren was born on December 6th, 1732, at Churchill, in Oxfordshire, his mother died, and his father left the village and went out into the world to seek a fortune which he never found. He died in the West Indies, without ever seeing his son again.

Young Warren remained at Churchill in the care of his grandfather till he was eight. He went to the village school where he sat on the same forms as the children of the peasantry. He lived at the rectory within sight of the Daylesford estate, which had formerly belonged to his family. He was told stories of the wealth and greatness of his ancestors, and, lying one day on the bank of a brook which flows into the Isis, he made a great resolve, child though he was. He determined to buy back Daylesford.

There certainly seemed little chance in those early days that the small orphan with the strange ambition would ever achieve his purpose.

When he was eight his father's elder brother, Howard Hastings, who was a customs' clerk in London, took charge of his education, and sent him to school at Newington, in South London, where he was well taught but ill fed. He grew up to be a short man, and he always attributed the smallness of his stature to the hard and scanty fare at this school.

After two years he was sent to Westminster School, where he distinguished himself, formed a friendship with the poet Cowper, and had every prospect of becoming a notable classical scholar. But his uncle Howard died, and the

Warren Hastings as a young man in India. From the painting by T. Kettle in the National Portrait Gallery

unfortunate boy came under the guardianship of a distant relative whose sole idea of his responsibility was to get rid of young Warren as quickly as possible. He determined to take the boy away from the school and send him off to India as a writer or clerk in the service of the East India Company.

The headmaster of Westminster School remonstrated strongly, declaring that Warren Hastings was likely to become one of the first scholars of the age, and he even offered himself to pay for the boy to go up to Oxford University.

But the guardian was adamant, and so Warren Hastings, after spending a few months at a commercial school in the study of arithmetic and book-keeping, was shipped off to India in January, 1750, when he had just entered his eighteenth year.

The voyage took long in those days, and it was not till October that he landed at Calcutta, and was at once placed at a desk with a big ledger before him. It was customary for a writer to serve five years in that capacity, and then to become a factor with higher pay. The wages were shamefully low, but the East India Company expected its officials to add to their incomes by making profits by private trading.

After three years at Calcutta, Hastings was sent to the factory at Kasimbazar, and did his work so well that after two years more he was promoted to a seat on the council of the factory.

Close by was Murshidabad, the headquarters of the Nawab who ruled three great provinces, and while Hastings was at Kasimbazar, Suraja Dowlah became ruler, declared war on the English, and captured and plundered every British factory in Bengal.

A Helping Hand from Clive

Kasimbazar was seized and Warren Hastings was sent a prisoner to Murshidabad. Owing to the intervention of some Dutch traders, he was treated well, and allowed a certain amount of freedom. Then came the tragedy of the Black Hole with the capture of Calcutta.

The English, who had taken refuge on a barren island in the mouth of the Hoogly river, wanted to learn something about the proceedings of the Nawab, and Hastings, after gaining much valuable information, fled to Fulda, and then when Clive appeared in the Hoogly with an army from Madras, he joined the force.

Clive soon perceived his value, and after the battle of Plassey, when Meer Jaffir was proclaimed Nawab in place of Suraja Dowlah, who had been assassinated, Hastings was sent to the Nawab's Court as agent for the East India Company.

For three stirring years Hastings remained at Murshidabad, and in 1761, after Clive's return home, he was promoted to a seat on the Calcutta Council.

Private trading on the part of the Company's officials was now carried on to a disgraceful extent, and it developed into what was little better than robbery of the native states committed most discreditably under the protection of the British flag.

Hastings felt the shame that these transactions brought upon the fair fame of England, and when he was sent by the Governor to see what could be done in the way of reform, he suggested that the trade should be regulated in such a way that while the Nawab and his subjects were protected from injustice, the East India Company should not suffer.

The Governor agreed, but the majority of the Council at Calcutta, which had the power to outvote the Governor, refused to sanction the arrangement. It was not a pleasant position for Hastings, for, while he was abused by his colleagues on the Council for partiality to the Nawab, he was denounced by the Nawab as a traitor.

"Of the conduct of Hastings at this time," says Macaulay, "little is known; but the little that is known, and the circumstance that little is known, must be considered as honourable to him. He could not protect the natives; all that he could do was to abstain from plundering and oppressing them, and this he appears to have done. It is certain that at this time he continued poor; and it is equally certain that by cruelty and dishonesty he might easily have become rich."

High Testimony

This is high testimony, and it is doubtful if it could be spoken of any other Indian official at that period except Warren Hastings.

When, in 1764, Hastings returned to England, he had only a small fortune, and this soon disappeared through his generosity to relatives. He remained at home for four years, and was then appointed by the Directors of the East India Company a Member of Council at Madras.

He went out and found the affairs of the Company in a state of chaos. Within a few months he had restored order, increased the dividends that could be sent home, and did so well that the Directors in London expressed their appreciation and promoted him to be head of the government of Bengal.

It was now that Warren Hastings began the great work of his life. The English had made themselves masters of a large part of India, but they still pretended to hold their lands as vassals of the throne of Delhi, and in all the revenues they raised they professed to be tax collectors appointed by the Mogul ruler. In public documents the name of the Nawab of Bengal was used, and yet in the government of the country, as has been truly said, he had less real share than the youngest writer or cadet in the Company's service.

The whole administration, except as regards military matters, was left to the natives, and the native administrator who had charge of these matters, and was stationed at Murshidabad, was responsible only to his British masters. The English, though supreme, had not assumed the style of sovereignty. It was an unsatisfactory arrangement, and Hastings determined that it must be altered.

With the approval of the Directors the office of native administrator was abolished, and the administration of the three provinces of Bengal, Orissa and Bihar was transferred to the servants of the East India Company. A new system of civil and criminal justice under English superintendence was set up, and thus the East India Company became in name as well as in fact the sovereign authority.

Of course, the only test of success which the Directors in London considered was that of money. If the officials in India sent home plenty of cash to provide dividends, then all was well. This put Hastings in a great difficulty. Good government cannot be carried on for nothing, and if justice is to be administered to all, then the people cannot be unduly squeezed so as to produce more and ever more taxes.

The captive Rajah escaped in the tumult and let himself down the steep banks of the Ganges

Hastings found himself with an empty treasury, and an unpaid army, and even his own salary was often in arrears. Yet there was an insistent demand from London to remit more and more money.

He reduced the allowance of the Nawab of Bengal by a half, and stopped the tribute which the Company had bound itself to pay to the Great Mogul at Delhi. These acts afterwards formed part of the charges of misrule brought against Warren Hastings, but it is difficult to know what else Hastings could have done.

The old double system of government, in which the native rulers were allowed to oppress the people so long as revenues were produced for the Company, could never have been continued, and with the English extending their territory and power it was obvious that they must take more responsibility.

During this transition stage, too, Warren Hastings was much condemned for having lent an English force to the Nawab of Oudh, in return for a payment of about half a million sterling. The army was required for the conquest of the Rohillas, who ruled the fertile valley of Rohilcund. Of course, such a proceeding would not be considered correct in these days, but things were different a century and a half ago. At any rate, even those who, like Lord Macaulay, condemn Hastings, agree that in less than two years after he assumed the government he had, without imposing any additional burdens on the people, added about £450,000 to the annual income of the Company, beside effecting large economies in administration.

Fettering the Governor

Just at this time the English Parliament began to concern itself with Indian affairs, and passed an Act declaring that the governor of Bengal should be styled the Governor-General of India, and should exercise control over the rest of the Company's possessions in the peninsula.

He was to be assisted by four councillors, who were named in the Act. But though he had a vote and a casting vote in case of a tie, he could be out-voted and his whole policy brought to naught if three of the councillors happened to vote against him. It was a ridiculous system, and led to endless trouble in the next few years.

A Supreme Court of Judicature, with a Chief Justice and three other judges, was also established at Calcutta, and made independent of the Governor General and his council.

One of the councillors who was appointed to act with Hastings was Philip Francis (afterwards Sir Philip), who appears from the first to have been a bitter enemy of Hastings, and did all he could to oppose him. Two other councillors, General Clavering and Mr. Monson, who had gone out in the same ship as Francis, seem to have been completely under the influence of Francis, and always joined him in voting against the Governor, who had only one councillor, Mr. Barwell, on his side. The result was that over and over again the councillors negatived the Governor's wishes, and prevented him from carrying out his financial and other reforms.

For example, when Hastings wanted to make special laws dealing with gang robbery, a very common form of crime in India, his council objected to the punishment of those who harboured the criminals, and so nothing could be done.

It was a humiliating position for a Governor-General, and the natives soon found it out. They regarded Warren Hastings as a fallen man, and began to come forward with all sorts of charges against him in order to please Francis and his friends, who treacherously listened to the native slanderers and treated them with consideration.

Dastardly Councillors

Among the accusers of the Governor-General was a native administrator named Nuncomar, who had been dismissed by Hastings. Believing that Hastings' days were numbered, Nuncomar made serious charges against him, which Francis and his friends decided should be inquired into with great ceremony.

Hastings declared the sitting of the council at which the inquiry began at an end, and left the room with Barwell, but the other members kept their seats, declaring that they formed the council, and then questioned Nuncomar, who brought charges of bribery against Warren Hastings, using forged documents to support his charge

It was a dastardly thing for these members of the council to take sides with an enemy against their Governor-General, but Hastings was not the man to remain idle. Just as the triumph of Nuncomar seemed complete and he began to hold daily levees to which not only his countrymen but Francis and General Clavering also went, Nuncomar was suddenly arrested by order of Hastings on a charge of felony, and committed with all speed to the common gaol

Calcutta was staggered at the news. The natives could not understand that there could be any authority independent of the council which had successfully opposed the Governor-General. Both they and Nuncomar had a shock, therefore, when the accused was indicted before the Supreme Court presided over by the Chief Justice.

The majority on the council opposed to Warren Hastings now acted more outrageously than ever, and heaped honours and rewards on the family of Nuncomar. When the trial came on, however, and he was charged with forgery, he was found guilty and sentenced to death. The sentence was carried out, and the contempt which the natives had long been showing for the Governor-General soon disappeared.

It is impossible in a few pages to go into the whole story of Hastings' career as Governor-General. Monson died, and then with Clavering and Francis voting on one side and Barwell and Hastings on the other, the casting vote of the Governor-General could be brought into use and gave Hastings for the first time a majority, which he was not slow to take advantage of. He carried out financial reforms, planned schemes of conquest which he lived to see realised, and arranged for alliances with various native princes.

An Unforeseen Resignation

Things were at last going well with him when he received a great shock. News came that his resignation had been accepted, that a new Governor-General named Wheeler was on his way out from England, and that meanwhile the supreme office was to be filled by General Clavering.

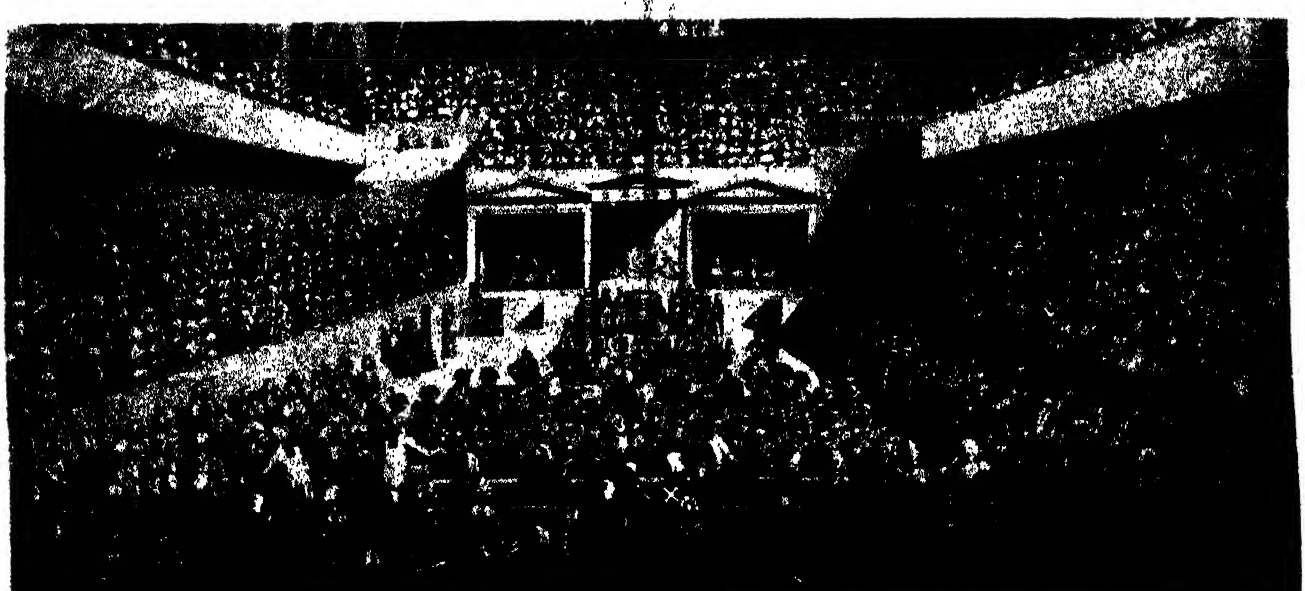
What could it all mean? Well, it appears that when a friend and subordinate of Hastings, Colonel Macleane, had returned to England, he had taken with him a resignation written out by his chief to be used only in case of great emergency. Macleane, finding that Hastings had enemies in England, had for some reason or other got the idea that his employer was to be dismissed and censured by Parliament. He therefore handed in the resignation, a document about the terms of which there seems to be some doubt, and which Hastings appears almost to have forgotten

Bold Measures Successful

This was certainly bad news for Hastings, and the whole incident seems to have been due to a misunderstanding. He declared that he had never given instructions which could warrant the steps which had been taken in England, and as his resignation was invalid all the subsequent proceedings were therefore null and void. He was still Governor-General, he declared, and had every intention of acting as such.

But Clavering decided to seize the supreme power. The general sent for the keys of the fort and treasury, took possession of the records and summoned a council at which Francis attended. Hastings held a council in another apartment with Barwell. Both parties, in the circumstances, had a good deal of right on their side, and the question was, who was to settle which council was the real one and to be obeyed?

Hastings very cleverly offered to submit the case to the Supreme Court, and to abide by its decision. Clavering and Francis had no alternative but to agree, and the court, which was favourably disposed towards Hastings, gave its uncompromising decision that he was still Governor-General.



The opening of the trial of Warren Hastings in Westminster Hall in 1788. Hastings is marked with a white cross

When Wheeler arrived in India, supposing himself to be Governor-General, he found that he would have to be content with a subordinate seat at the council board.

Trouble now broke out in the south of India, and had it not been for Hastings it is a question whether India might not have been lost to Britain. Hyder Ali, the ruler of Mysore, was a great power, and the most formidable enemy the English have ever had to encounter in India.

Hastings would undoubtedly have made a friend of him, or if that was impossible, have vigorously opposed him. The English in Madras, however, did neither the one nor the other. They roused his hostility, and took no proper steps to meet the army of 90,000 men which he led into the plains of the Carnatic. This army had a hundred cannon, and was led by French officers. Everywhere Hyder Ali was successful, and fort after fort fell into his hands.

A hostile French expedition was expected from Europe, and England, now engaged in war at home, could do nothing to help her distant dependencies.

Genius and Courage

"Then it was," says Macaulay, "that the fertile genius and serene courage of Hastings achieved the most signal triumph. A swift ship flying before the south-west monsoon brought the evil tidings in a few days to Calcutta. In twenty-four hours the Governor-General had framed a complete plan of policy adapted to the altered state of affairs. The struggle with Hyder was a struggle for life and death. All minor objects must be sacrificed to the preservation of the Carnatic. The disputes with the Mahrattas must be accommodated. A large military force and a supply of money must be instantly sent to Madras. But even these measures would be insufficient unless the war, hitherto so grossly mismanaged, was placed under the direction of a vigorous mind. It was no time for trifling. Hastings determined to resort to an extreme exercise of power, to suspend the incapable governor of Fort St. George, to send Sir Eyre Coote to oppose Hyder, and to intrust that distinguished general with the whole administration of the war."

This plan proved successful, the progress of Hyder was arrested, and a great victory retrieved the honour of English arms.

Hastings had stupendous difficulties to encounter. He must find the money for carrying on the government of Bengal, and at the same time he must finance the costly war in the Carnatic, and further send the usual remittances to England. But, nevertheless he was equal to all this.

Later he was greatly condemned because he took from the mother and grandmother of the Nawab of Oudh a large sum of money which they had wrongly appropriated. Quite contrary to their Moslem law they had converted a large part of the treasure left by the late Nawab to their own use. With the approval and assistance of the existing Nawab, Hastings made the Begums, as the princesses were called, disgorge a great part of this treasure. Afterwards the enemies of the Governor-General invented all sorts of stories telling how the treasure had been extracted from the princesses by improper means, exaggerating the amount obtained, and pretending that these avaricious women were martyrs. They certainly had no legal right, according to their native law, to the land and money which they had held.

When Hastings left the House of Peers, all the Lords rose and removed their hats

It was unfortunate, however, that the three hostile members of his council, out-voting Hastings merely because they wanted to baulk him, had a long time before guaranteed the property to the princesses, despite the fact that Hastings from the beginning had opposed such a guarantee.

When the Governor-General, in order to resist the French in India, demanded large sums from the Rajah of Benares, that ruler attempted to bribe Hastings with £20,000 in order to obtain some indulgence. Hastings took the money, handed it over to the Company's treasury, and then insisted that the Rajah should comply with the demands of the English Government.

The Rajah was fined for delay and at last he paid the money. Owing to the need of an increased army to resist the enemies of England, Hastings made further demands upon the Rajah, Cheyte Sing, and then went to Benares to interview him.

He met the Rajah, who received him with great reverence, but made excuses for not paying. Hastings determined to take strong measures, and ordered his sepoys to arrest the Rajah.

When the news became known in the city a vast crowd gathered in the streets around the palace, and soon a fight began, which ended in a massacre of the small British force.

The captive Rajah escaped in the tumult, and let himself down the steep bank of the Ganges by means of a rope made of the turbans of his attendants. A boat was in waiting, and in this he escaped to the opposite shore.

Hastings with fifty men was still in the palace, and when the Rajah from the other side of the river sent apologies and offers of money, his messages were not even acknowledged.

Hastings was not only a brave man, but fertile in resource. Many natives of India wear large golden earrings, and when they travel they lay these aside for fear of robbery, and insert a small roll of paper in the pierced part of the ear. Hastings wrote notes to the commanders of the English troops at various stations, rolled them up and placed them in the ears of his messengers.

Routing the Rajah

Meanwhile, the Rajah, finding himself with a large army and the Governor-General apparently at his mercy, became threatening, but the messengers of Hastings got through, and very soon a brave and skilful soldier, Major Popham, came to his rescue and the army of the Rajah was put to rout. He fled from his country, never to return, and Benares was added to the British Dominions.

Meanwhile, Francis, who had been wounded in a duel with Hastings, had gone home to England, and there spent his time in blackening the character of his former chief, and making base insinuations against his integrity. It was like Francis, who could never be loyal to anyone. He is believed to be the author of the Letters of Junius, which created such a sensation when they attacked the government of the day, including some men who had befriended Francis.

Hastings remained at the head of the Government of Bengal till 1785, and then, having brought peace to the country and raised the prestige of England to a height which it had never reached before, he returned home, leaving behind a reputation such as no white man had ever won in the East.

Even half a century after he left the natives of India spoke of him as the

greatest of the English, and nurses sang children to sleep with a rhyme about the fleet horses and richly caparisoned elephants of "Sahib Warren Hostein." He was certainly popular with the mass of the people, whose in terests he had done so much to uphold.

When he finally left, all kinds of people, European and native alike, lined the quays, and he was presented with many addresses which eulogised his work.

After four months' voyage Hastings landed at Plymouth in June, 1785, and went to London, where he was received with distinction by the King and Queen and thanked by the Directors of the East India Company. It looked as though he would receive a peerage and live the rest of his life as an honoured English statesman. His ability certainly would have been of untold value to the Government.

But it is said that William Pitt was jealous of him, and when Edmund Burke and others, prompted and urged on by Philip Francis, the old enemy of the Governor-General, gave notice in the House of Commons of a motion to impeach Hastings, Pitt stood aside instead of supporting him.

The opposition to Hastings grew, all kinds of discreditable motives and actions were attributed to him during his rule in India, and at last the great Governor-General was im peached and brought to trial before the House of Lords. It is the greatest trial in English history.

The Seven Years' Trial

It opened on February 13th, 1788, in Westminster Hall, amid military and civil pomp. The thoroughfares leading to the Hall were kept clear by cavalry, and grenadiers lined the streets. The peers, robed in gold and ermine, were marshalled by heralds, and the judges in their state robes were present to give advice on points of law. Nearly 170 lords marched from the House of Peers in solemn procession to the hall of trial, where the galleries were crowded with a distinguished audience, which included the Queen, the Princesses, the Ambassadors of the great European Powers, and indeed all the most distinguished people of the day.

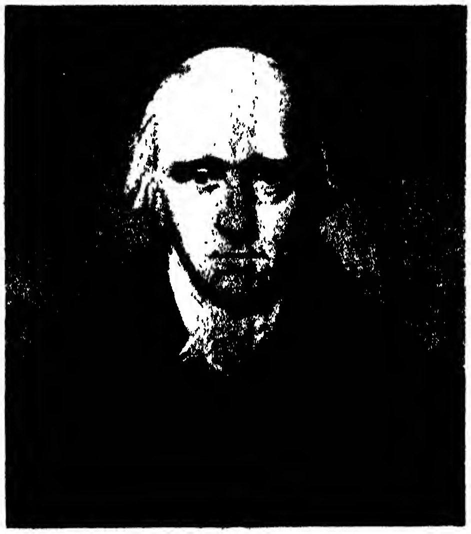
Macaulay tells us that when Hastings advanced to the bar and bent his knee he looked like a great man and not like a bad man. He was small and emaciated, but he conducted himself with dignity.

At this trial the greatest orators of the day, Burke and Sheridan and Fox, made long speeches, and it is said that on some days as much as fifty guineas was paid for a single ticket to get into the hall, which was crowded to suffocation.

With many adjournments, the trial went on year after year, until at last, in the spring of 1795, nearly eight years after Hastings had been brought by the Serjeant-at-arms of the Commons to the bar of the Lords, the verdict was given.

Many of the peers who had sat at the opening of the trial were now dead, and only 29 peers voted, of whom 23 found Hastings "Not Guilty." He was called to the bar and informed that the lords had acquitted him, and was solemnly discharged. After bowing respectfully he retired. Hastings himself declared that the arraignment had taken place before one generation and the judgment was pronounced by another.

But the trial had almost ruined Hastings. It had cost him £70,000 to defend himself, and he was left as he himself declared with no means of subsistence. His friends rallied round him, and the East India Company came generously to his assistance. They proposed to pay the costs of the trial, and to grant him an annuity of £5,000. But the Board of Control, at the head of which was a man named Dundas, who had himself been a party to the impeachment, refused to give its consent to what, after all, was only just.



Warren Hastings in his old age From the painting by Sir Thomas Lawrence

A long dispute arose and meanwhile poor Hastings was in such distress that he could hardly pay his weekly bills. At last it was arranged to settle an annuity of £4,000 on him, and so that he might meet his debts he was to be given ten years' annuity in advance. The Company was also allowed to lend him £50,000, which was to be repaid free of interest.

It was a miserable compensation to an abominably treated statesman, of which the Government and Parliament of the day should certainly have been ashamed. Hastings himself had always been a most generous giver to others, and now at any rate he could end his days in peace. But he never received the peerage which was his due, and the only honour conferred upon him was that he was made a Privy Councillor.

At last, on August 22nd, 1818, in his 86th year, he died peacefully and was buried in the chancel of Daylesford Church. He had achieved the ambition of his childhood and bought back and improved the Daylesford estate, which had belonged to his ancestors.

Perhaps the proudest moments of his life were on two afternoons, one in March and one in April, 1813. On the afternoon of March 30th he was examined in the House of Commons as a witness in connection with the renewal of the charter of the East India Company, and as he entered he was received with acclamation by the Members, and, after giving his evidence, as he retired the Members rose and uncovered their heads.

A few days later, on April 5th, he attended the committee of the Lords, and while being examined was allowed a chair, a most unusual concession. Then, when he left, all the Lords rose as the Commons had done and removed their hats. These two expressions of respect were such as had never before been accorded to any subject.

Warren Hastings was a great Englishman and a great Empire builder. We largely owe our supremacy and our success in ruling the millions of the Indian peninsula for a century and a half to this able and disinterested man.

Even Lord Macaulay, who adopts many of the false or exaggerated charges of the enemies of Hastings, had to acknowledge his ability and success.

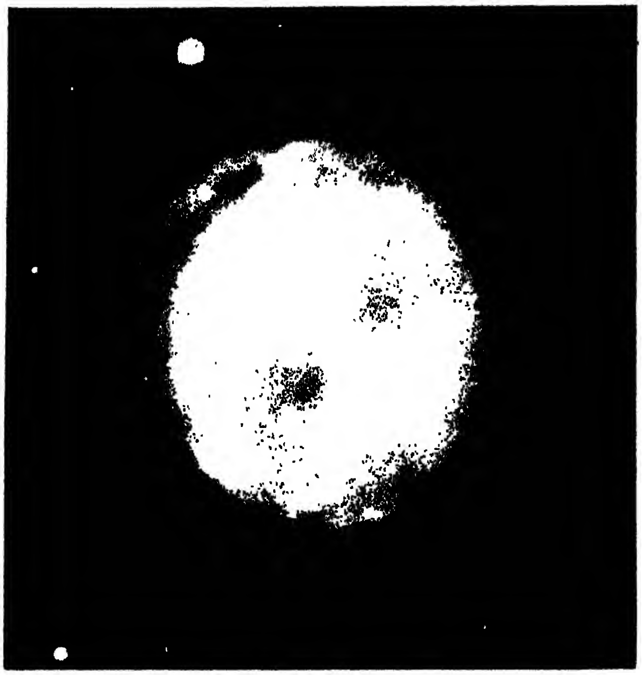
High Testimony

"His internal administration, with all its blemishes," says Macaulay, "gives him a title to be considered as one of the most remarkable men in our history. He dissolved the double government, he transferred the direction of affairs to English hands. Out of a frightful anarchy he educed at least a rude and imperfect order. The just fame of Hastings rises still higher when we reflect that he was not bred a statesman; that he was sent from school to a counting-house, and that he was employed during the prime of his manhood as a commercial agent far from all intellectual society. No complication of perils and embarrassments could perplex him. For every difficulty he had a contrivance ready, and whatever may be thought of the justice and humanity of some of his contrivances, it is certain that they seldom failed to serve the purpose for which they were designed."

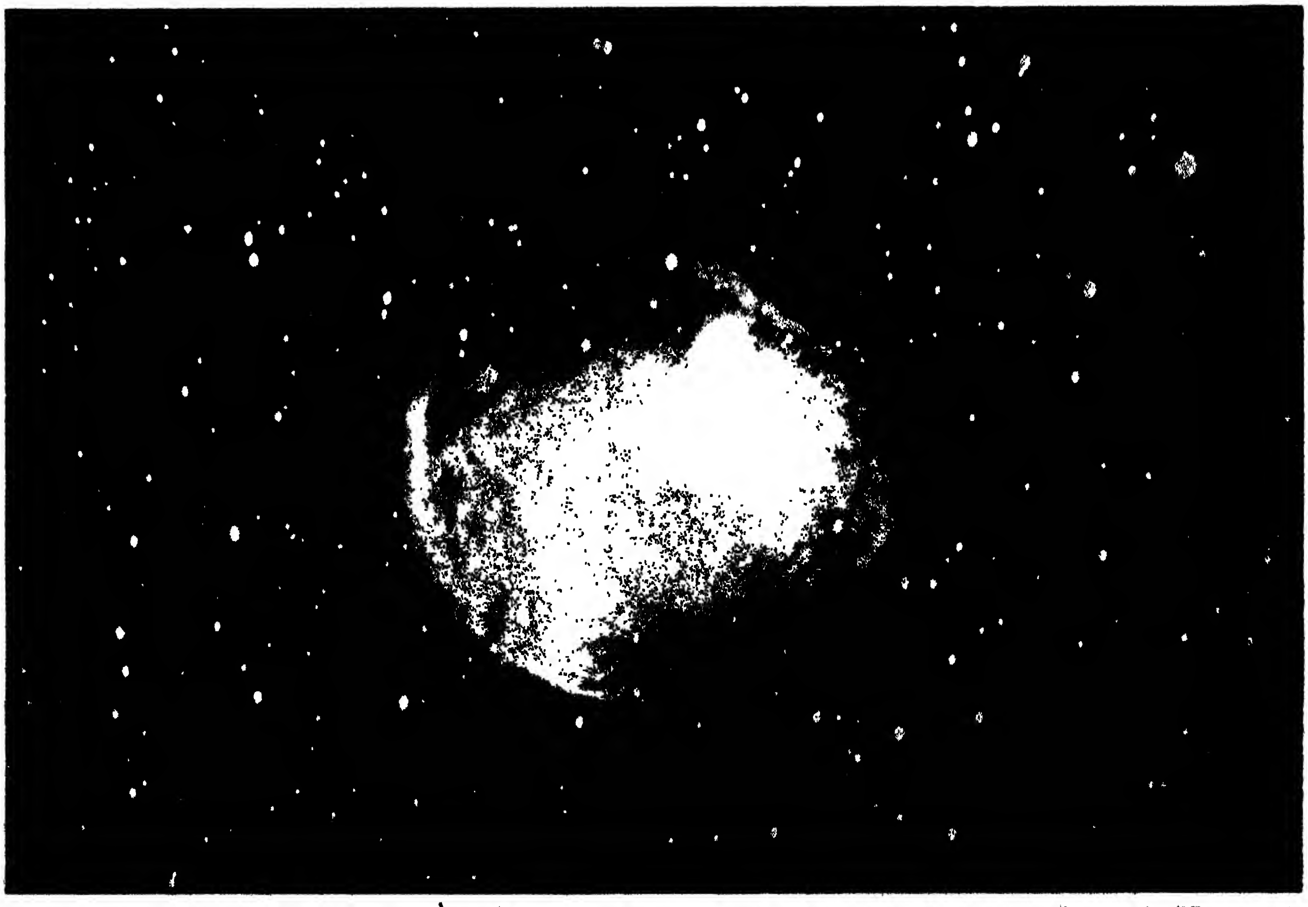
Macaulay concludes with the words: "We cannot regard without admiration the amplitude and fertility of his intellect, his rare talents for command, for administration, and for controversy, his dauntless courage, his honourable poverty, his fervent zeal for the interests of the State, his noble equanimity, tried by both extremes of fortune, and never disturbed by either."

This is high testimony from one who was certainly no friend of the Governor-General.

THE OWL, RING AND DUMB-BELL NEBULAE



In addition to the nebulæ which are of spiral form like those shown on page 1151, and the great irregular nebulæ like those shown on pages 198 and 984, there are others which are named from the curious shapes they have assumed. Some of these are shown on this page. The left-hand photograph here is of a nebula in the Constellation of the Great Bear, and is known as the Owl Nebula, because it has the appearance of an owl's face. The photograph on the right is known as the Annular or Ring Nebula in the Lyre Constellation



This photograph shows a nebula known from its shape as a Dumb-bell nebula. There are several such to be seen in different parts of the heavens, the "handle" joining the two ends of the dumb-bell being very faint in some cases. This photograph was taken at the Lick Observatory in California, and the two photographs above are given by courtesy of the Royal Astronomical Society

WONDERS OF THE SKY

MILLIONS OF UNIVERSES IN THE MAKING

Ever since man began to make discoveries in the heavens, he has been more and more amazed at what he has found there. But no discoveries have been so astonishing as those of recent years in connection with the nebulæ, which, as we read here, prove to be vast universes like that of our Milky Way system, but at incredible distances away in Space

The giant telescopes that are now at the disposal of the astronomers have revealed about two million nebulæ in the heavens. These objects are so distant as to be invisible to the human eye, even when aided by a powerful telescope, and it is only when photography is brought into co-operation with the telescope, and a long exposure given, that we can get a record of the nebulæ.

As we read on pages 197 to 200 the nebulæ are really other universes like our Milky Way or Galactic system, either made or in the course of making. The marvel is that by studying the photographs of these nebulæ, which in size, shape and brightness are very varied, we can see a universe in the making at almost every stage of its remarkable history.

Dr. Hubble, of the Carnegie Institution Observatory at Mount Wilson, has arranged the photographs of the various kinds of nebulæ in a sequence from which it is possible to see the gradual development of a universe from a vast mass of glowing gas to an ordered system of cart-wheel form like our own Milky Way.

A series of these photographs, taken with the aid of the great 100-inch telescope at Mount Wilson Observatory, is given on page 1152 by courtesy of the Carnegie Institution of Washington, and in this series the making of a universe can be clearly followed and understood.

A universe such as our own starts as a vast mass of gas of almost incredible size which, by the pull of gravitation among its various parts, assumes a globular shape. It is set in motion and as its matter condenses it shrinks and the speed of its motion increases.

This causes the vast globe of glowing gas to flatten just as our Earth flattened at the poles owing to its rotation when in the fluid state. The faster the speed of a rotating body the greater is the flattening, and that is why the planet Jupiter, which rotates faster than our Earth, is more flattened.

The story of the formation of a universe from a mass of glowing gas and its successive stages has been worked out theoretically by the distinguished English astronomer Sir James Jeans with the aid of mathematics. His results correspond with amazing closeness to the actual forms of nebulæ that have been photographed.

These are two spiral nebulæ seen in the constellation of the Great Bear. That on the left is one of the most beautiful "star cities" out in Space and was the first nebula that was seen to be rotating. Its light takes 1,600,000 years to reach us. In the outer regions of this Universe are countless swarms of stars like those in our Milky Way. In the photograph on the right we see clearly the arms being thrown out all round as the nebula rotates with something of the appearance of a catherine wheel

The round, fuzzy mass of glowing gas gradually becomes flattened more and more, till at last it assumes the shape of a flat cart-wheel with a hub round which the rest rotates

Sir James Jeans describes the various stages of change.

"At first," he says, "the spinning mass simply flattens and assumes the shape of an orange. After a time a new feature appears—a pronounced bulge all round its equator. Finally this becomes so marked that the equator is merely a sharp edge; the rotating mass has assumed the shape of a double convex lens

Changing Shape

"This configuration forms a noteworthy landmark in the evolutionary path of a nebula. Until it is reached the effect of the shrinkage can be adjusted, and is adjusted by a mere change of shape—in spite of its reduced size the rotating mass carries the same angular momentum as before by the simple expedient of rotating more rapidly and bulging out its equator. But we find that this is no longer possible when once this landmark has been passed."

Further shrinkage, Sir James Jeans explains, now involves an actual break up of the nebula. It is like a fly-wheel that is rotating too fast for safety, and it relieves the situation by the ejection of matter from its equator. The last three photographs in the middle column on this page show the successive stages of this operation.

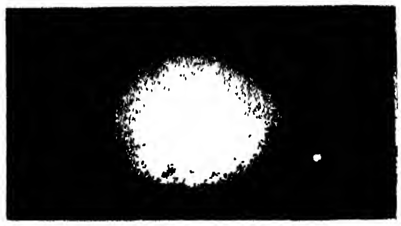
Just as a fly wheel bursts at its weakest point, so there must be some reason why the whirling nebula throws off matter at one or more points of its equator and not equally all round.

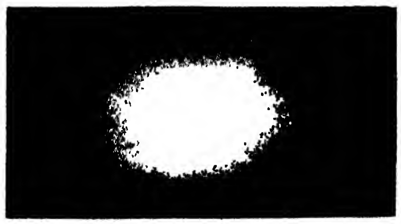
We know how the attraction of the Moon and Sun causes tides on the Earth, which bulges as the water, and to a less extent the land, is drawn up by the pull of the Moon and Sun.

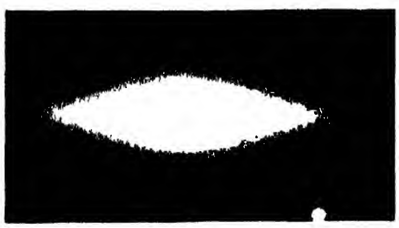
Well, in the same way, the attraction of other heavenly bodies in Space causes what may be described as tides in the nebula. The result is that the equator of the nebula instead of being circular becomes elliptical and it is the parts farthest from the centre where the nebula's gravitational pull is weakest that are thrown off like arms, as can be seen in the photographs on page 1151

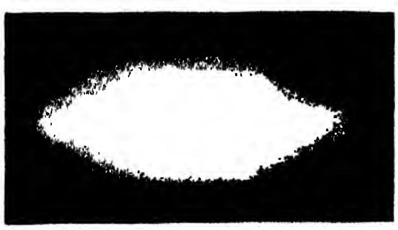
These arms, pulled out of the mass of gas by the tidal action of other heavenly bodies, gradually condense and form stars like our Sun

The process is continued and other passing stars pull out arms of gas from the condensing stars of the nebula, forming in course of time bodies like our planets Then from the planets in their fluid state are drawn out arms of gas which eventually condense into satellites like our Moon









Such is the story of the formation of the Universes, as worked out theoretically by astronomers and confirmed, as far as anything can be confirmed, by observation of the nebulæ in different stages of development.

While the nebulæ appear to differ greatly in size and brightness, Dr Hubble declares that it is clear these variations are due to differences in distance.

It is possible to estimate with fair accuracy the distances of the various nebulæ The faintest of all that can be recorded by means of the 100-inch telescope are the farthest away, and are at the amazing distance of 140 million light-years. Seeing a light-year is 5,876,068,880,000 miles, the distance of these far-away universes is nearly 823 million million, million miles

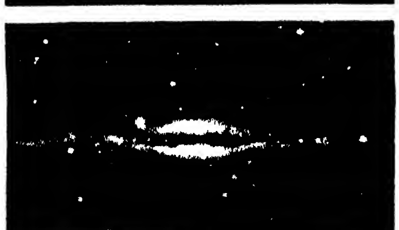
A Model of Space

Dr. Hubble, who has made a special study of the nebulæ, tells us that they are fairly uniformly placed in Space at an average distance of about 1,800,000 light-years apart, and Sir James Jeans helps us to realise what this means

"To construct a model," he says, "we may take three hundred tons of apples and space them at about ten yards apart, thus filling a sphere of about a mile diameter This sphere is the range of vision of the 100-inch telescope; each apple is a nebula containing matter enough for the creation of several thousand million stars like our Sun; and each atom in each apple is the size of a solar system with a diameter equal to, or slightly larger than, that of the Earth's orbit."

The mass or quantity of matter in a nebula is no less wonderful than its size and distance. One nebula is estimated to have 3,500 million times the weight of the Sun, and another 2,000 million times the Sun's weight.

The more we learn about the marvels of the heavens and the wonders of space, the more we are inclined to say with the psalmist of old: "When I consider Thy heavens, the work of Thy fingers, the Moon and the stars, which Thou hast ordained, what is man that Thou art mindful of him?"



The six photographs in the middle column show a sequence of shapes into which the greater number of nebulæ can be arranged. It begins with the globular fuzzy mass of gas, having little or no rotation; and ends with the flat cart-wheel type like our own Milky Way system, which rotates much more rapidly It is believed that this sequence represents stages in the mechanical evolution of a Universe. The three photographs in a line at the bottom show three nebulæ all in the same stage, but seen from different angles The dark bands of the two lower photographs in the middle column are condensed matter on the outside of the nebular equators. These photographs and those on page 1151 are given by courtesy of the Carnegie Institution of Washington

WONDERS of ANIMAL & PLANT LIFE

THE RABBIT AS A PET AND A PEST

To most English boys and girls the rabbit is best known as a rather attractive pet. It can be kept quite easily and healthily in a comparatively small space and large numbers are reared in our towns as well as in the country for both pleasure and profit. But the rabbit can be a great pest by destroying trees and other vegetation, and in Australia and New Zealand, as we read here, it has proved a real menace to the farmers

As in the case of the dog and cat, under domestication the rabbit has developed into various forms, and is in many ways different from its wild relative. For instance, while the wild rabbit's ears are held upright above the head, many of the domestic breeds have one or both ears drooping and are known as lop-eared varieties. In others, such as the Angora, the fur is much finer and more plentiful than in the wild rabbit.

Whether domestic or wild, however, the rabbit is a complete vegetarian, and it is this fact that makes it in some districts such a great pest to the farmer and gardener. It eats up the garden vegetables of all kinds, it does great damage to the trees by gnawing round the bark, and it damages the ground by burrowing and undermining it.

But in Great Britain, fortunately, the rabbit pest is kept within reasonable limits, because the animal has many enemies apart from man. Weasels, stoats, and pole-cats all prey upon the rabbit and find its flesh good. The fox, also, does not disdain a rabbit when nothing more substantial is available, and even hedgehogs will carry off a young stray rabbit and make a meal of it.

Then there are the hawks and owls which, whenever they get a chance, swoop down and carry off a rabbit for a meal. Domestic cats also will often loiter round a rabbit warren in order to capture the animals as they come or go. In this way, although the rabbit multiplies at an enormous rate, its numbers are kept within reasonable limits. Nevertheless, in Scotland during the past century, it has multiplied very greatly.

The Dangerous Rabbit

It is, however, in other lands to which the rabbit has been taken by man and where few, if any, natural enemies exist, that the little animal, so attractive in England, has become a positive danger and menace to the community. We must remember that the animal begins to have young when it is only six months old, and it has four or five litters in a year, each numbering from five to ten animals.

A pair of rabbits, then, living in favourable circumstances and free of natural enemies, would in three years have multiplied into 13,718,000. This being so, we can understand why it is that vast districts in Australia and New Zealand, where the animals had no enemies, were in a few years completely overrun by rabbits.

Early in the nineteenth century some settlers introduced two or three pairs of rabbits into Australia, thinking they would be very useful as they multiplied, to provide food and sport. Within a year or two of the rabbits being let loose, whole districts had become nothing but gigantic rabbit warrens.

The people soon found that the rabbits ate the grass which was needed for the sheep, killed the trees by barking them, and devoured all kinds of fruits and vegetables which had been destined for human needs. The rabbits were caught and killed in millions, and after a few years, more than a million skins were exported every year.

Still the rabbits multiplied, and soon in some districts farming became impossible, and the farmers were ruined by the pets that had become pests.

"No fence will keep them out," wrote a distinguished visitor to Australia. "If they cannot fly over it they will burrow under it like moles, and nothing is safe from them." At last the Government had to take up the matter. A reward of £25,000 was offered for the extermination of the rabbit, and Monsieur Pasteur, the famous French chemist, suggested the introduction of rabbits inoculated with disease. An Australian professor also suggested the same method, but it proved unsuccessful.

In New Zealand the destruction by rabbits became so great that it was at one time suggested that people should vacate certain districts.

In 1952 some success followed the innoculation of captured rabbits with a virus, and then releasing them to infect others. But the chief methods of killing them is by trapping or shooting. Great drives are held and millions of them are canned for export. The skins are an important export from both Australia and New Zealand.

A Law Against Rabbits

The money received, however, from the sale of frozen rabbits, canned rabbits, and rabbit skins, does not pay a hundredth part of the loss and damage which the rabbits cause. Farmers and graziers in Victoria, South Australia, and New South Wales, have to spend large sums every year in destroying rabbits, driving them out of their burrows and waging war upon them in all sorts of ways. The law says he is to clear his land of the vermin, but, of course, this is impossible. He keeps them under, however, as much as possible for his own

The rabbit, though not fond of the water, is a good swimmer and, if necessary, will always take to the water to escape from an enemy such as a dog

The rabbit is also a good climber, and often climbs up inside a hollow tree for safety if pursued, or to make a nest

HOW MAN HAS CHANGED THE RABBIT'S EARS

The rabbit is believed to be a native of the Western Mediterranean countries, but it has spread to many other parts and has been carried by man to Australia, New Zealand, the Falkland Islands, and other distant regions, in some of which it has become a great pest. In the wild state the rabbit has upright ears which, when extended, measure about eight inches across and it weighs about three pounds.

By selecting rabbits with special characteristics and colouring, man has been able to breed animals that are very different from their wild ancestors. Altering the appearance of an animal this way is called selective breeding, and one result is shown in the above photograph of a rabbit whose ears from tip to tip have the enormous span of 26 inches. Its weight is twice that of a wild rabbit.

sake as much as in obeying the law.

In order to keep the rabbits out of Northern Queensland and Western Australia enormous fences, thousands of miles long, have been erected by the Government. One great fence put up by the Western Australian Government reaches from the Australian Bight in the south to a point 1,200 miles away on the north-west coast, but the rabbits managed to get past the fence, although it reaches three feet in height and is buried some distance under the ground. The fence has, therefore, been duplicated a few miles further west, and throughout its whole length this great double barrier is patrolled daily by men whose special duty it is to keep it in repair and to kill any rabbits seen.

In rabbit-infested Victoria, it is an offence punishable by a fine of £100 to keep a rabbit as a domestic pet. Yet soon after their introduction into Australia rabbits had been protected by law, and could be killed only in season.

It is not quite certain of what country the rabbit is a native, but it is believed to have originated along the western shores of the Mediterranean, where it is still abundant today. Some say the Romans introduced it into Britain. It is curious to read that in Spain, where the climate and vegetation are not unlike that of Australia, there was a serious rabbit pest 2,000 years ago when the country was a province of the Roman Empire and one of the chief granaries of Europe.

Much of the damage done to trees by the rabbit seems to be wanton, but probably the little animal gnaws the bark in order to wear down its sharp front cutting teeth, which grow rapidly. A wild rabbit was found some time ago that had a front tooth in its upper jaw which did not quite meet that in the lower, and so could not be worn down. It, therefore, grew and grew in a curved direction till at last it entered the rabbit's neck.

The growth goes on whether the teeth be used or not, and so the rabbit must constantly be wearing away the edge to prevent this becoming a danger.

Rabbits are excellent swimmers, but they will not take to the water unless they are obliged. If, however, a dog pursues a rabbit near a river, the rabbit will at once plunge in and swim to the opposite bank. They are also good climbers, and when driven to the necessity can climb rapidly up a tree. They sometimes even climb up the inside of a hollow tree to make a nest.

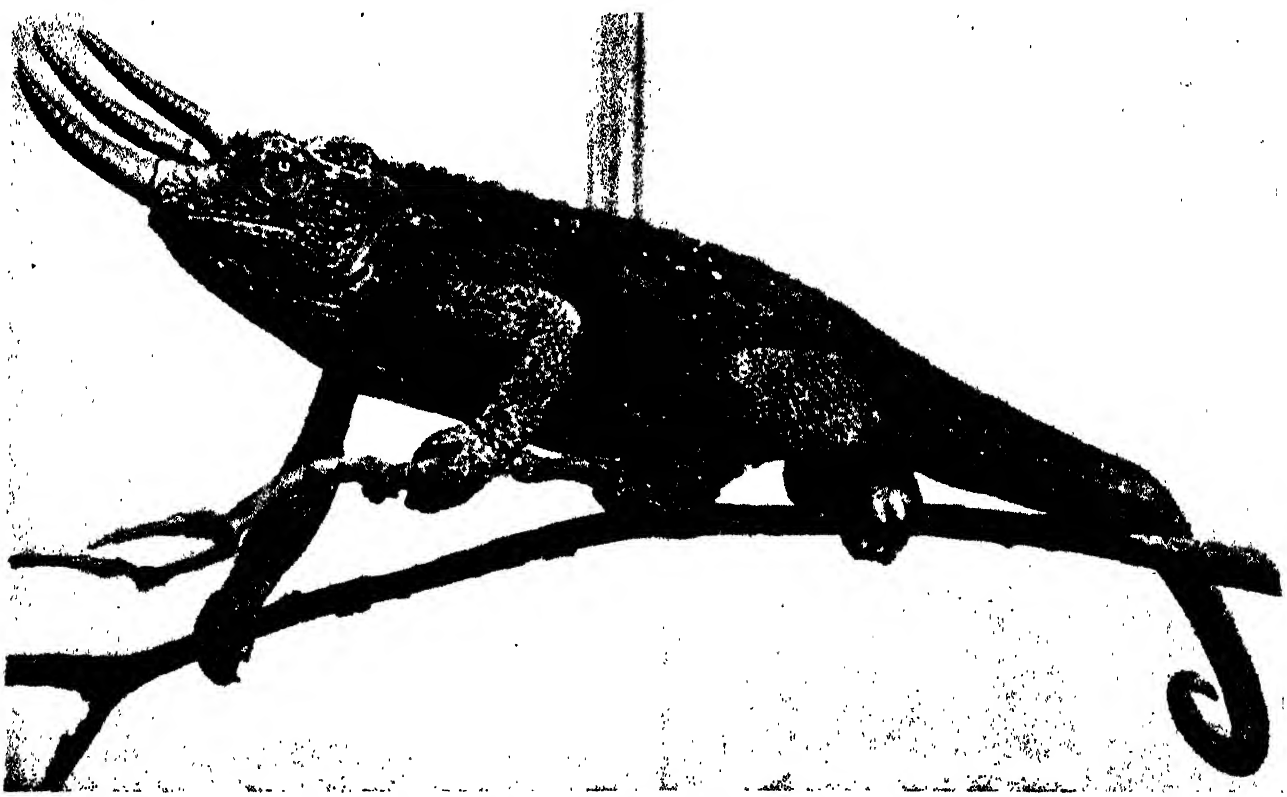
Generally, however, the mother digs a burrow and lines the extremity with dried grass and down plucked from her own body. Then, after producing her family, she goes out, closing the opening with earth in order to guard it, as far as possible, from such enemies as stoats and weasels. It is said that afterwards the mother only visits her family once in every 24 hours.

When digging its burrow the rabbit pushes the earth out behind it, and then spreads the ejected earth over the surrounding ground with its forefeet, so as to remove all traces of the earth having been removed.

Generally speaking, rabbits are very timid creatures, but the editor of this book possessed a wild rabbit which had been caught young and was allowed to run freely in his garden during the daytime, but was shut up in a hutch at night. One morning when he went to release the rabbit for the day a large rat was found in the hutch lying dead. It had evidently got in after the rabbit's food, and in some way the rabbit had killed it, presumably by kicking it with its powerful hind legs.

This same rabbit became so tame that when any member of the household went to the garden door and called "Bun! Bun!" it would run up immediately for food. The rabbit also liked to play with a little Pomeranian dog and would run round and round the dog, constantly touching it with its paws. Sometimes the dog, not wanting to play, would get angry and snatch a mouthful of fur from the rabbit, but this did not scare the rabbit

A HORNED CHAMELEON LIKE AN ANCIENT DINOSAUR



We all know the ordinary European chameleon that has a curious swivel eye, changes colour to suit its surroundings, and darts out a long tongue to catch insects. Well, here is an African relative that lives in Kenya and has strange horn-like projections on its head. Only the male has these growths. Most chameleons lay eggs, but the female of this species produces its family alive

POISONOUS AND DANGEROUS PLANTS OF

There are many common plants growing wild in Great Britain that are poisonous and harmful to man and often to beast, too, and on these pages thirty-six of them are shown so that we may be able to identify them. Hemlock Water Dropwort is sometimes mistaken for celery, and it has poisoned cattle as well as humans. Monkshood or Aconite is the most dangerous of all our native plants, all parts being poisonous. Cowbane roots have sometimes been mistaken for parsnips and killed those who ate them. The same tragic result has followed the eating of Fool's Parsley roots for turnips. All the other plants shown above have proved fatal except Spurge Laurel and Greater Celandine, and they have caused serious illness

THE BRITISH FIELDS, LANES AND WOODS

All the plants on this page, when eaten, have led to serious and many of them to fatal results. Deadly nightshade is a very dangerous plant in all its parts, and the very poisonous berries are particularly attractive to children. Yew leaves are poisonous and the seeds in the berries are harmful. Dwarf elder flowers, leaves and bark, are poisonous, and the berries should be let severely alone. Fine-leaved water dropwort is very poisonous and has paralysed horses. Even such familiar flowers as Foxglove, Daffodil, Wild Hyacinth or Blue-bell are poisonous. Cattle have been killed by eating Pasque-flower. Baneberry berries are highly poisonous, and all the other plants shown here are sufficiently poisonous to be dangerous if eaten.

THE ROMANCE OF THE EARTHWORM

The common earthworm is not a very attractive-looking creature and most people express disgust when they see a worm crawling over the surface of the ground.

But really this despised and lowly creature is an exceedingly useful friend of man and its life is a great romance which has been revealed to us by Charles Darwin, the distinguished scientist.

Without the worm we should find it much more difficult to raise sufficient food crops, for the earthworm prepares the soil and does it in a much more efficient way than any agricultural implement or machine that has ever been devised by the inventive genius of man.

More than a century and a half ago Gilbert White, the famous naturalist of Selborne, wrote that "earthworms though in appearance a small and despicable link in the chain of nature, yet if lost would make a lamentable chasm. Worms seem to be the great promoters of vegetation, which would proceed but lamely without them, by boring, perforating and loosening the soil, and rendering it pervious to the rains and the fibres of plants, by drawing straws and stalks of leaves into it, and most of all by throwing up such infinite numbers of lumps of earth called worm-casts, which is a fine manure for grain and grass."

It was not till a century later, however, that the enormously important part which worms play in making the earth fertile was fully known through the patient work of Charles Darwin, spread over many years. He wrote a whole book on earthworms and their work, which is one of the most fascinating stories of natural history in the world.

How the Worm Travels

It will be well worth our while to look out for a worm in the garden and study its form. We shall probably find one on the surface of the ground after a heavy rain, for then the burrows get filled with water and the worms come out so as not to get drowned.

We shall see that the worm's body is made up of a large number of rings, sometimes as many as two hundred, and on each of these rings there are eight little bristles or hairs. If we take an earthworm from the garden path and stroke it gently to and fro on the under-surface, or move our fingers from the tail towards the head, we shall feel these hairs. What are they for?

Well, they are the organs of locomotion of the worm, enabling it to pull itself along, and, if we place a worm on a sheet of paper we shall hear the hairs rubbing against the paper as the worm moves forward.

The worm makes a burrow for itself two or three feet deep, and sometimes deeper. If the soil is soft it just bores down head first, but if the ground is hard it eats its way through the earth, passing the matter through its body, including its gizzard, where it is ground up, and after the nourishment is extracted from the animal and vegetable remains, the rest is passed out of the body, and we see it in the form of worm casts on the lawn or elsewhere. A sticky substance exuded from the worm's body lines the burrow and prevents the earth falling in.

The worm spends most of the day in its burrow but at night comes out to feed on decayed vegetable matter, often keeping its tail in the burrow and sweeping the ground all round as it searches for the food. In the day the mouth of the burrow is often closed with dead leaves.

By burrowing in the soil the worm enables air and water to penetrate everywhere, and permits delicate roots to travel about in the earth. Then by the falling in of burrows the whole soil is kept moving so that every grain is exposed to the action of air and rain. The decaying leaves carried down into the burrows by the worms manure the soil, and the deposit of castings at the mouths of the holes covers the surface of the ground with a fine rich soil.

Darwin's patience in studying the work of the worms was enormous. He covered over part of a field with broken pieces of chalk and left it for thirty years. Then he dug up the ground and found that by the action of the worms a layer of lumps of chalk had been carried down seven inches below the surface.

Another field was covered with hard flints and left for a similar period. At the end of that time the flints had disappeared below the surface and a horse could gallop over the field without striking its hoof on a flint

Squares of ground were marked out on different kinds of land and these were examined every day for a year and the worm castings counted and weighed. On one square yard the castings for a year weighed 3½ pounds. At this rate the worms bring up to the surface seven tons of earth on every single acre of ground.

A section through the soil showing earthworms in their burrows and their casts of earth on the ground. One burrow is closed with a leaf. A famous scientist calculates that there are, on an average, 50,000 earthworms to a single acre of land

Darwin concludes the account of his experiments with the words: "When we behold a wide turf-covered expanse, we should remember that its smoothness on which so much of its beauty depends, is mainly due to all the inequalities having been slowly levelled by worms.

The Lowly Ploughman

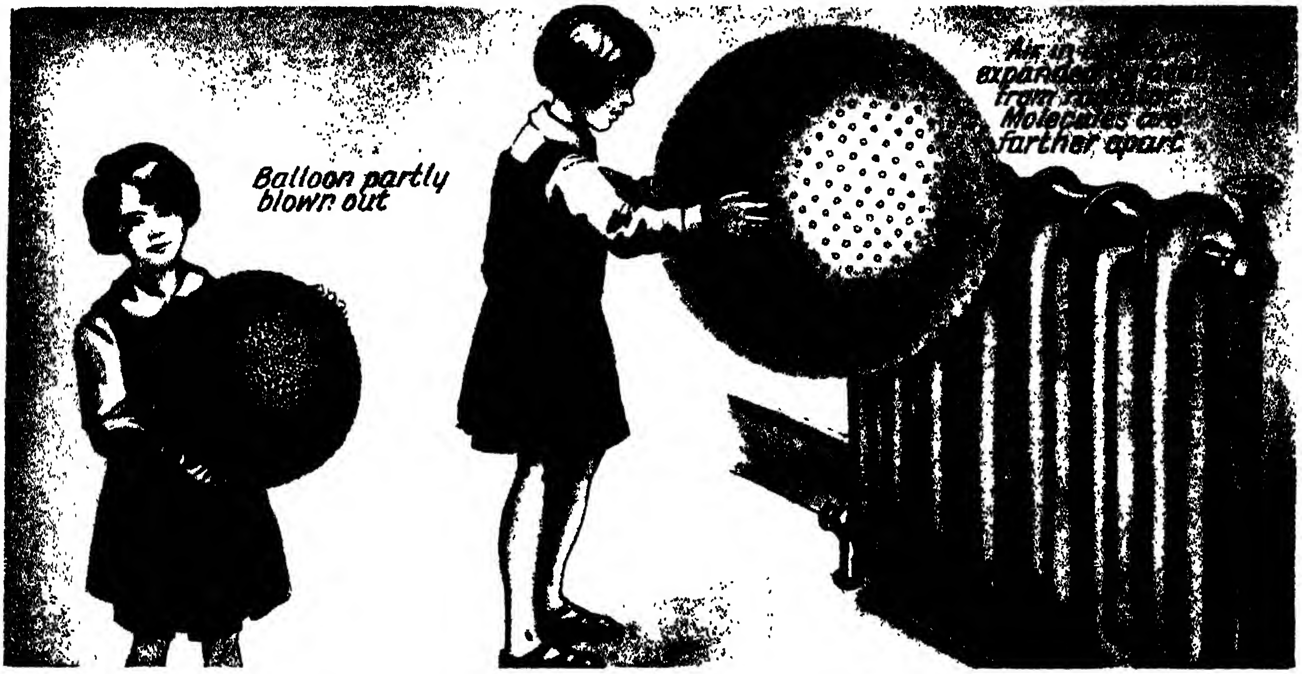
"It is a marvellous reflection that the whole of the superficial mould over any such area has passed and will again pass every few years through the bodies of worms. The plough is one of the most ancient and valuable of man's inventions; but long before he existed the land was in fact regularly ploughed and still continues to be ploughed by earthworms. It may be doubted whether there are many other animals which have played such an important part in the history of the world as these lowly organised creatures."

Worms are found in nearly all parts of the world, even on mountains up to 10,000 feet. They are not found in deserts, however, for in order that they may thrive there must be a certain amount of moisture in the soil. Otherwise they cannot make their burrows.

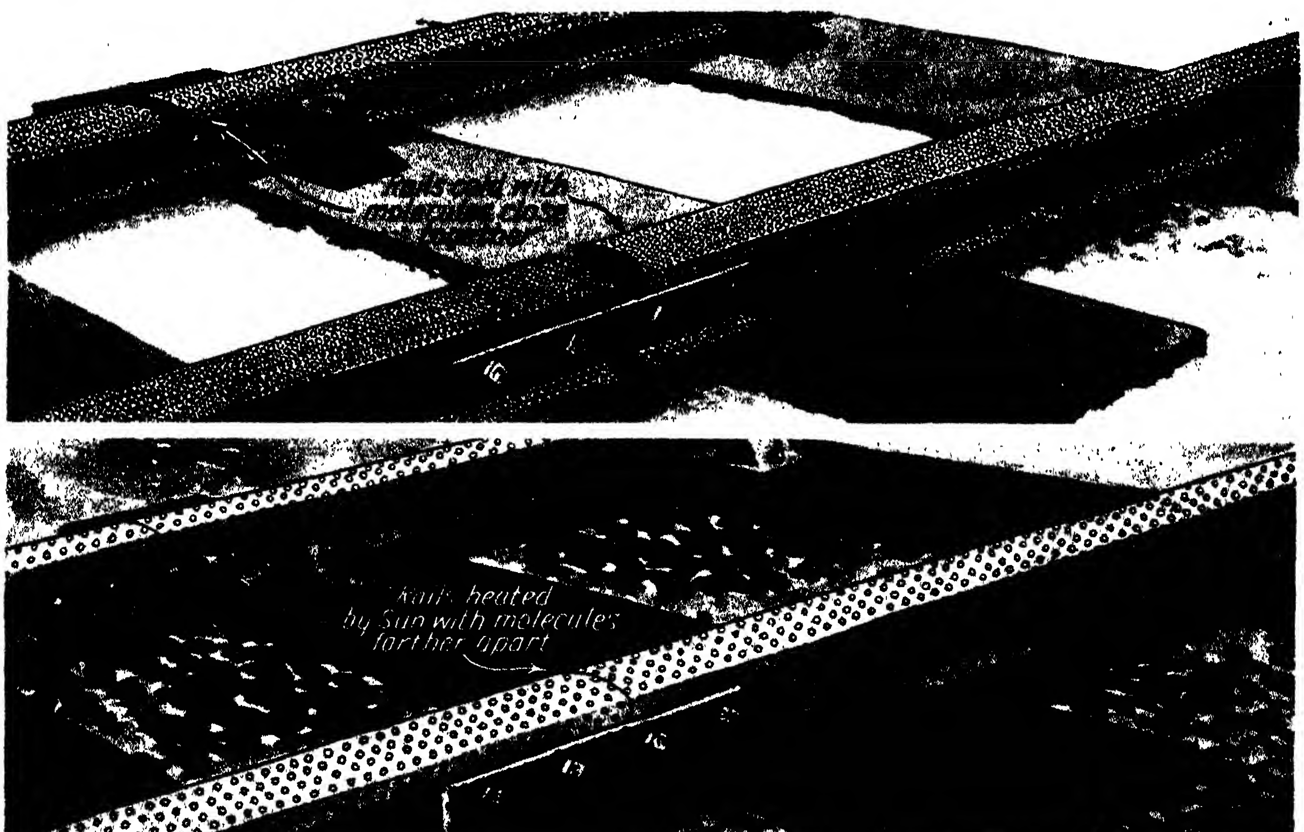
THE BIGGEST BEETLE IN THE WORLD

How would you care to live in a country where there were beetles as big as rats? In Brazil and Guiana there is a South American beetle known by scientists as Titanus giganteus, or the Giant Titan, which grows sometimes to a length of nearly nine inches. Specimens half a foot long are quite common. Here is a specially large specimen given natural size, and we can compare it with the sixpence placed alongside which is also reproduced exactly to size. The Giant Titan is the biggest of all beetles

HOW HEAT CAUSES A GAS AND A SOLID TO EXPAND



If we take an ordinary rubber balloon and blow into it we can fill it out to a certain size. Then, if we take this balloon and hold it near a warm radiator or some distance from a fire, being careful not to go too near, we shall find that the balloon will gradually get bigger and bigger, and if we hold it in the warmth too long it may even burst. The reason is that the molecules of air in the balloon are made to move to and fro more and more rapidly, and as they require increased space in which to do this, the air in the balloon occupies a larger volume than it did when it was cooler



We have probably noticed that the rails on which the train runs are not fitted close together—there is always a space between the individual rails. This is to allow for the expansion of the metal when the hot sun shines upon it. If we look at the track on a hot day we shall find that the ends of the rails are much closer together than they are on a cold and frosty day. The metal expands as it gets warmer because the molecules of which it is composed are vibrating with increased motion, and as they require more space for their movement the great mass of metal requires more room, and so increases in size

WHY HEAT MAKES THINGS BIGGER

Heat is really energy and the energy takes the form of motion among the molecules of which a body is made up. This is one of the remarkable discoveries of modern times. It used to be thought in the olden days that heat was a substance like air or water which got into a body, but we know better nowadays. One of the various and interesting results of heat is described on this page

We must all of us be aware that when things get hot they almost invariably get bigger; or, in other words, they occupy more space.

We see this in the thermometer. As the temperature rises and the mercury or alcohol in the bulb gets warmer, it occupies more space, and therefore rises in the tube.

The same thing is true of a solid and of a gas. When the railway men lay the track and place the metals on which the train is to run end to end, they always leave a certain amount of space between the ends of the rails to allow for the expansion of the metal when the Sun shines upon it in hot weather.

If they did not do this, the result would be that on some very warm summer day the rails all along the line would expand, and as there would not be room for them to extend lengthwise, they would have to buckle up to some extent and the track would then become dangerous.

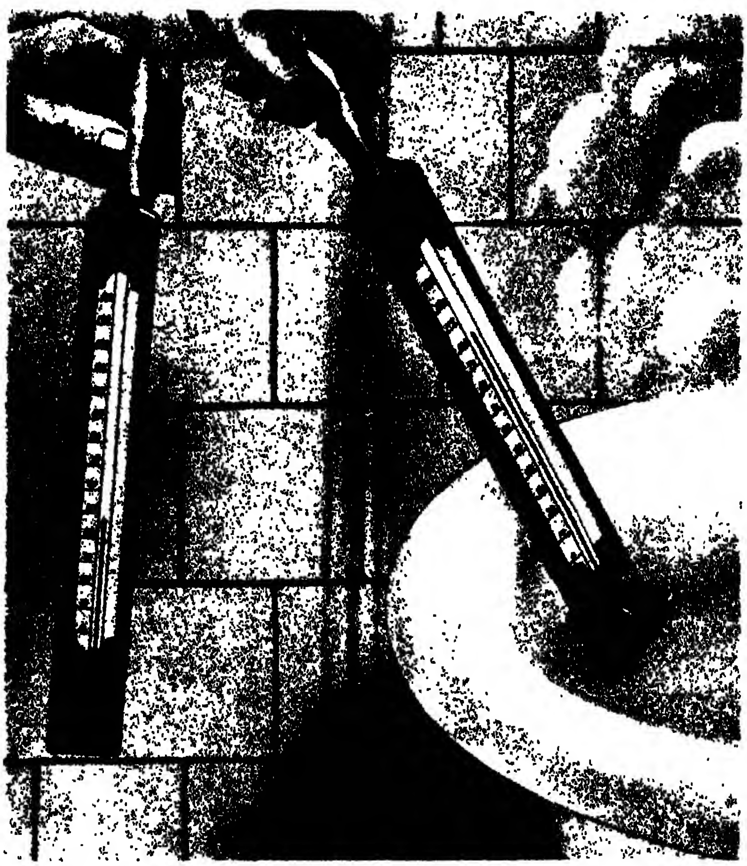
In regard to a gas, if we blow up a child's rubber balloon to about half its usual capacity and close the opening, we can expand the balloon a great deal more by holding it near a hot radiator or some little distance from a fire. The gas inside the balloon gets hot and expands, puffing out the balloon more and more as it does so. The increase of the space occupied owing to the heat is more manifest in the case of the air inside the balloon than in that of the steel rail or even the alcohol of the thermometer.

Now why does a substance need more space as it gets hotter? In the old days men of science thought that heat was a material like water, and that a body increased in size as it got hotter for the same reason that a dry sponge gets bigger when it is immersed in water. They supposed that the substance of the heat was added to the substance of the other material and so caused more space to be necessary for the combination of the two.

We know better in these days. Heat is not a substance at all; it is merely a state of matter. All substances are made up of molecules, tiny particles, of which we read on page 145.

Now, although an object like a steel rail may appear to be very still, the molecules of which it is made up are really moving to and fro, or in other words they are vibrating. When a substance becomes hotter through combustion, or when the hot sun shines upon it, the vibrations of the molecules are increased; that is, they are moving to and fro much more rapidly. And the movement increases more and more as the material becomes more heated.

This increased movement requires more space as the molecules are driven farther and farther asunder, and so the whole body which the molecules make up has to increase in volume. If it is a solid it increases in length and breadth and thickness, and if it is a liquid or a gas it increases in volume; that is, in all directions where it is free to move.

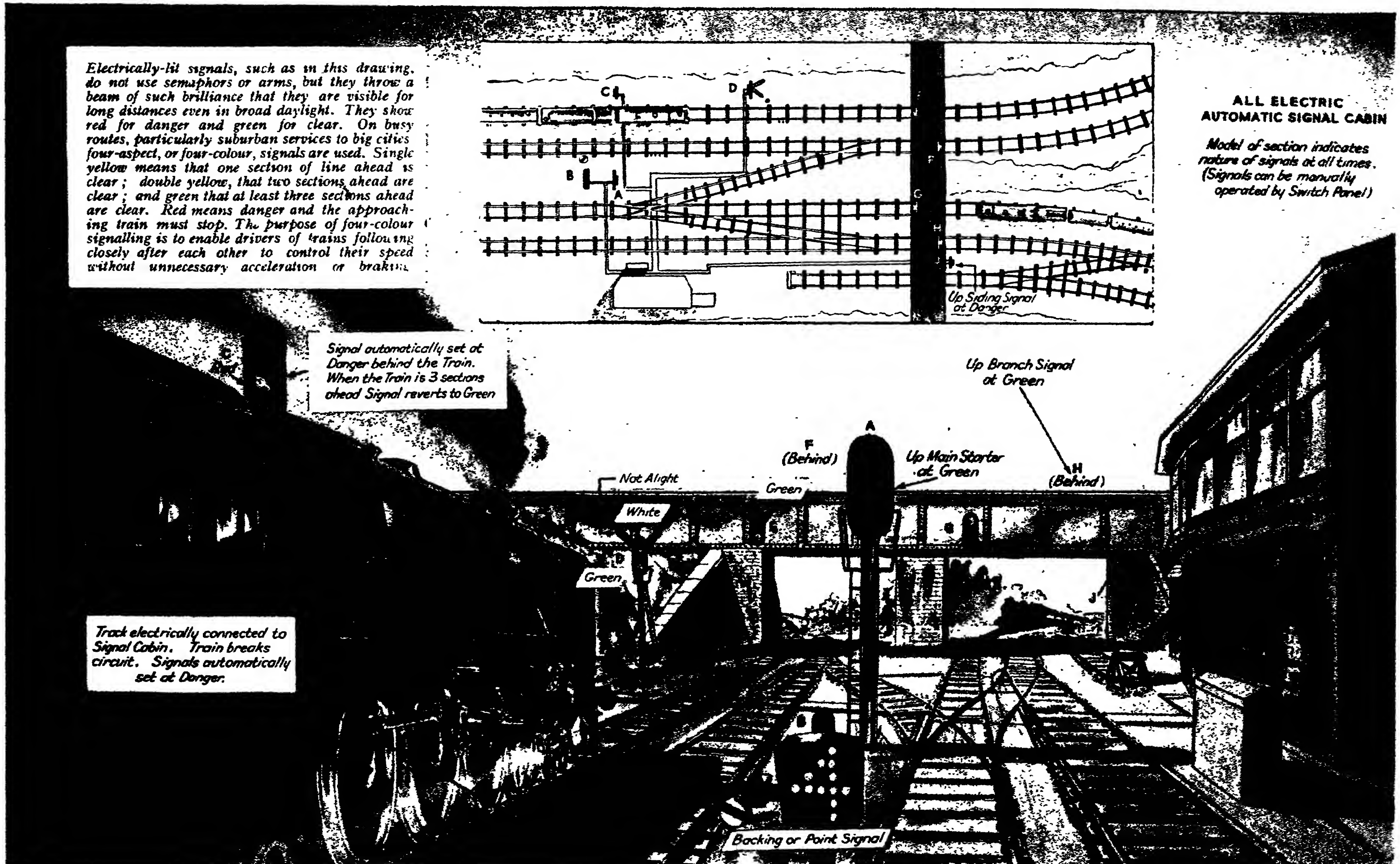


This simple experiment enables us to see that heat increases the volume of a liquid. When we put the thermometer into the hot water of the bath immediately the alcohol or mercury in the bulb increases in volume, and we see it expand and run up the glass tube, as shown in the right-hand picture

If the heat continues to increase, the movement of the molecules becomes so great that the force of cohesion is at last overcome and the heated body, if a solid, loses its rigidity and becomes liquid. If it is still further heated, it will cease to be a liquid and become a gas, and enormous heat like that found on the Sun may even break up the molecules of matter.

We speak of various bodies as being good or bad conductors of heat. What do we mean by this? Well, the spread of heat through a body such, for example, as a bar of iron is due to a gradual communication to the molecules in the bar, of the vibratory motion from the heated part to the remainder. By saying that a body or substance is a good conductor of heat, we mean that it is one which readily takes up and transmits the vibratory motion from particle to particle, while a bad conductor is one in which the motion is transmitted only with difficulty.

HOW TRAINS AUTOMATICALLY SET SIGNALS AT DANGER



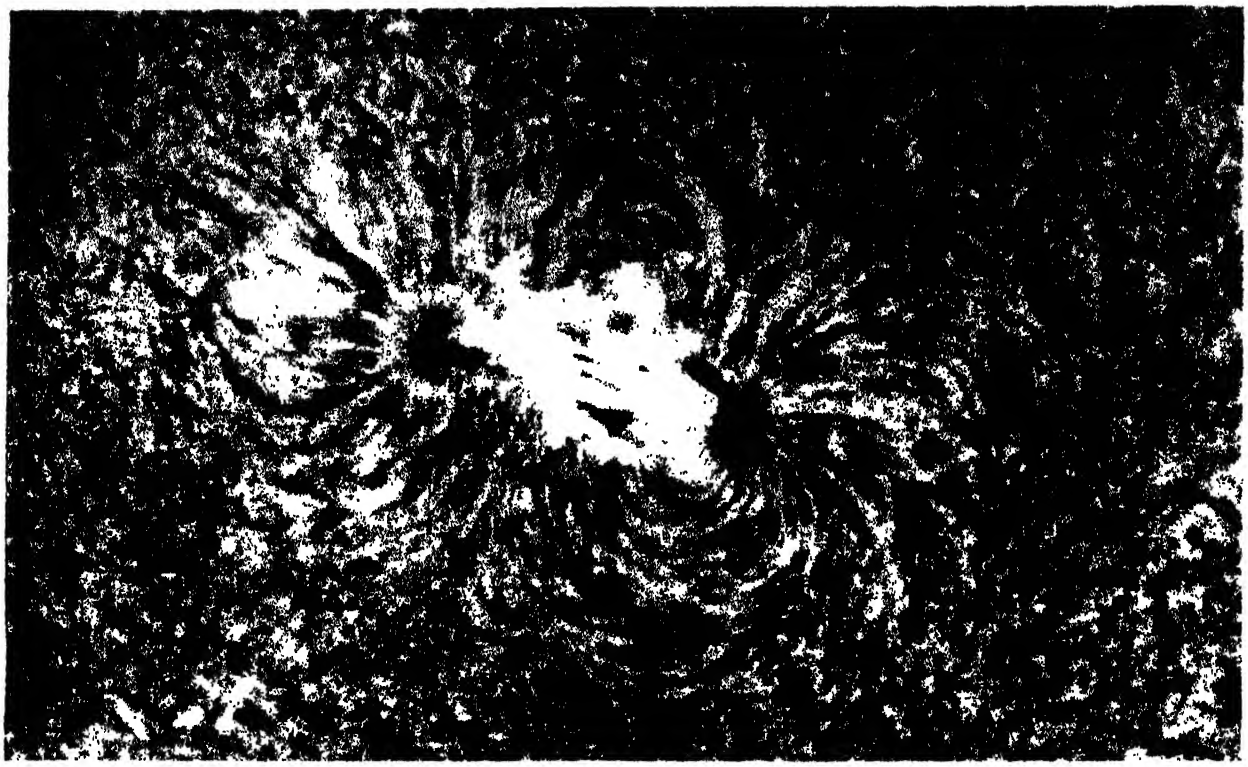
Although railway signalmen are expert and careful, there is always the chance they may make a mistake, and the safest system of signalling is one operated by the trains themselves. This drawing **shows you how trains automatically control the signals** governing their movement along the tracks. **The automatic action is done by what is called track circuiting.** The two rails of one set of track **are made to carry a weak electric current, but each length of rail is insulated from the other**

When a train is running or standing on a track through which current is passing, the current is short circuited through the engine and cannot be conducted along the track behind the train. When the current stops passing along the track, an electro-magnet is released to operate a device on the stop (red) signal behind the train and set it at danger. The signal stays at danger until the train in front has passed out of the section, when the signal automatically returns to safe (green).

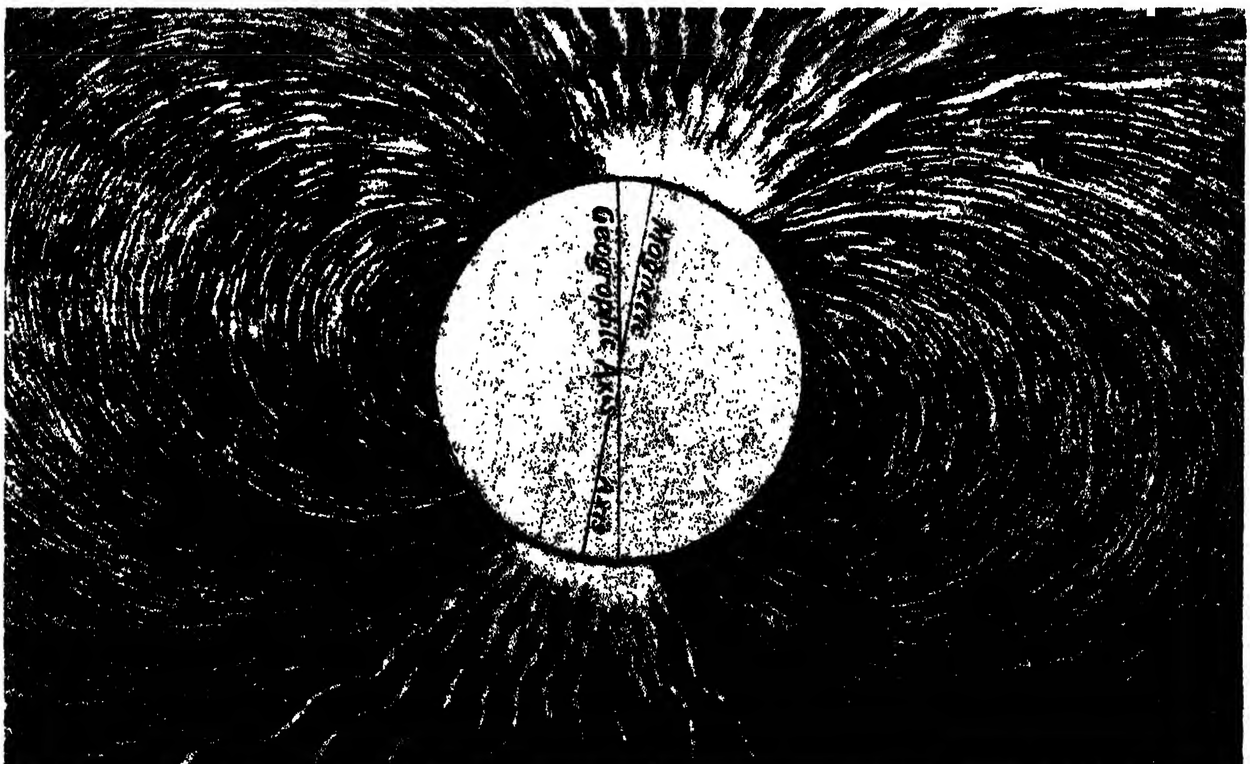
WHY THE BARGE GOES STRAIGHT ON THE CANAL

This picture-diagram shows why it is that a horse walking on the tow-path of a canal and pulling a barge by means of a rope, can draw the barge up the canal on a straight course instead of pulling it in towards the bank. The course is kept straight by means of the rudder which is set parallel to the direction of the rope. The barge is then acted upon by two forces working in different directions, first the rope, which tends to pull it towards the left bank, on which the horse is walking, and secondly the water pressing against the rudder and tending to turn the barge towards the right bank. By drawing two lines to represent these forces and directions, and constructing on them a parallelogram, the diagonal of this parallelogram will give us the direction in which the barge must travel. Men of science call this the resultant of the two forces acting on the barge. The parallelogram of forces comes into many departments of life. We see another example on page 1202, where two boys are kicking a football in opposite directions, and it travels along the diagonal

SUNSPOTS AND THE EARTH'S MAGNETISM



A group of sunspots photographed at the Mount Wilson Observatory of the Carnegie Institution. The whirling nature of these gigantic tempests on the Sun can be clearly seen in the photograph which shows as irregular white patches the immense hydrogen flames hurled up from the surface. These great seething areas are very often big enough to swallow up a dozen or more Earths



All about our Earth is a magnetic field or area subject to magnetic influence, and it extends far out into Space. Four thousand miles above the Earth's surface it is one-eighth as intense as at the surface. In this diagram, given by the courtesy of the Carnegie Institution of Washington, it is shown as made up of innumerable lines of magnetic force radiating from the Earth's magnetic poles

WONDERS OF THE SKY

HOW THE SUN AFFECTS YOUR RADIO

It is not surprising to know that radio transmission is affected by the Sun, for, as we read here, the radio waves travel in the same upper layer of the Earth's atmosphere as is bombarded by electric particles thrown out by the sunspots. These particles, on impact with the atmosphere, have very marked magnetic effects. All the photographs and diagrams in this and the previous and succeeding pages are given by courtesy of the Carnegie Institution of Washington

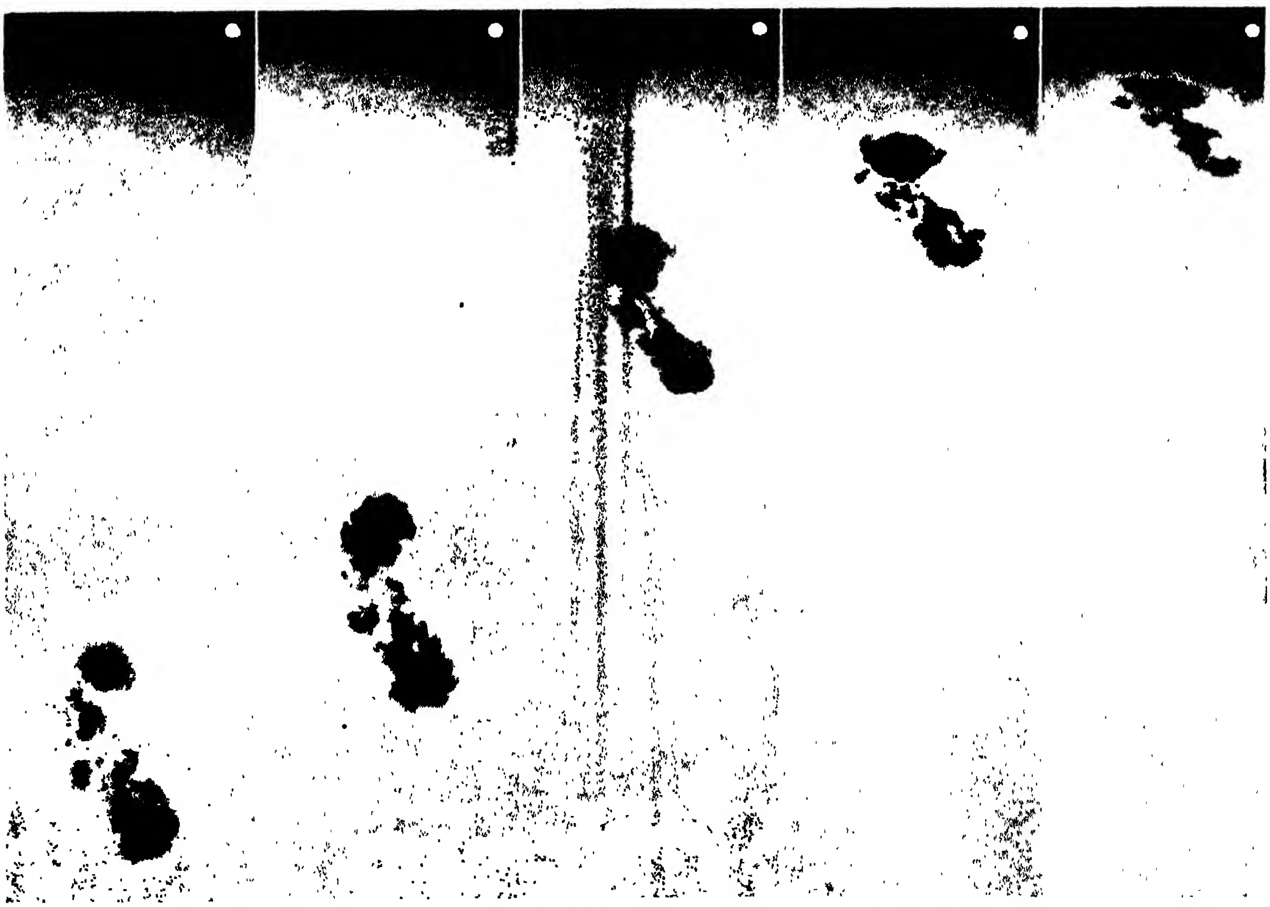
THE changing spots on the Sun's face about which we read on pages 367 and 368 are often so large that they can be seen without the aid of a telescope. Of course, when we look at the Sun we must always use a piece of smoked glass so as to shut off its glare, otherwise we may injure our sight. If, however, we smoke a piece of glass over a candle flame we can look at the Sun's face with perfect safety, and, as likely as not, we shall be able to see quite clearly one or more groups of sunspots.

If we can see a spot it is interesting to watch its progress from day to day, for all these spots seem to move across the Sun's disc from east to west. This movement is due to the Sun's rotation on its axis, and some spots pass right across the disc till they disappear over the western edge, and then after about a fortnight reappear on the eastern edge and begin the journey again. It is because of this passage of the spots that we know the Sun rotates.

The curious thing about the Sun is that the whole of it does not seem to rotate in the same period. At or near the equator the passage of a sunspot is about 27 days, but midway between the equator and the poles the period is about a day longer. Spots are very rarely seen any nearer the Sun's poles than that.

The period during which a sunspot lasts varies a great deal. Sometimes after passing off the western edge of the disc it never reappears, whereas some spots have appeared again and again and have lasted for more than six months. Why this should be no one can say.

We have already seen that the sunspots have a great deal to do with the appearances of the Aurora or Northern and Southern Lights (see pages 806 to 808), and also affect our weather to some extent (see pages 1028 and 1029). It is, however, with the magnetic



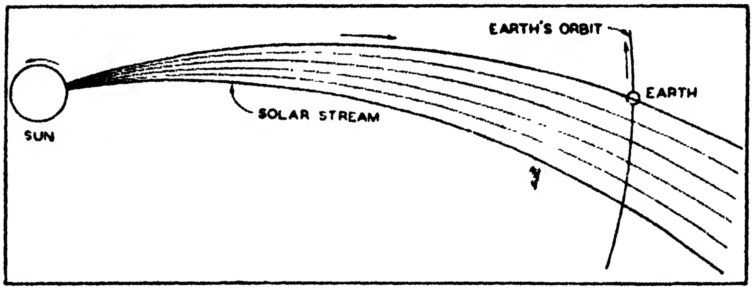
A series of direct photographs of a sunspot group taken at the Mount Wilson Observatory, U.S.A., on the 9th, 10th, 12th, 13th, and 14th of the same month. We see the change in position of the group as the spots are carried across the disc by the rotation of the Sun. The small white spots above represent the Earth drawn to the same scale as the sunspots. Sunspots vary in size from a few hundred miles in diameter to 50,000 miles across ; therefore many of them could easily swallow up our Earth and some of the planets.

influence of the sunspots that our Earth is chiefly concerned.

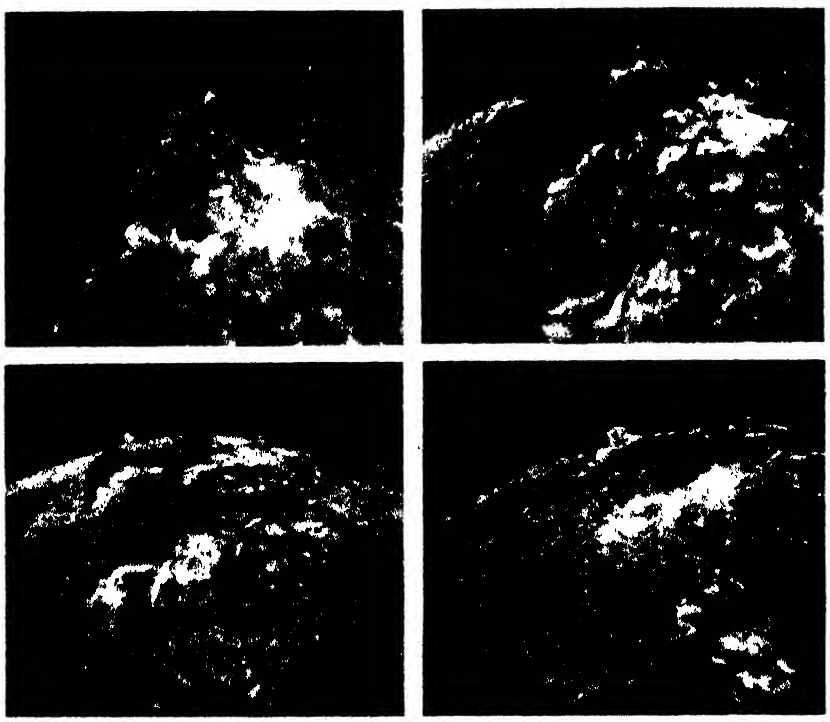
Streams of particles like electrons and ions (the electrified particles into which a substance is broken up by an electric current) are thrown out by sunspots travelling through Space and enter the ionosphere, the upper layer of the Earth's atmosphere, as explained in page 801.

They make their presence felt, however, for when they collide with the gases in the upper atmosphere they produce the auroral displays, and electric currents set up by this collision cause disturbances in the Earth's magnetic field.

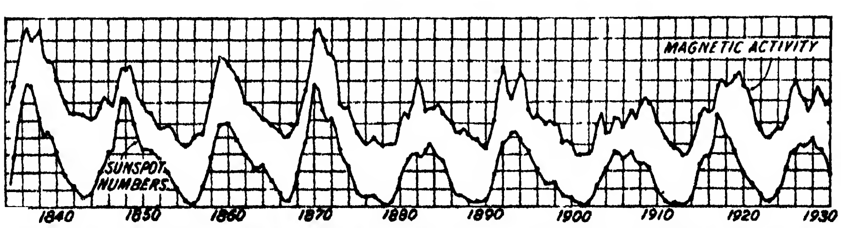
The auroral displays are rarely seen outside the polar regions, but the magnetic disturbances are felt everywhere, and observatories all over the world watch for these and record them. They are detected at once by means of very delicately suspended magnets. Sometimes the motions of the magnet are small, but at other times they are very violent, and men of science then say that there is a magnetic storm. It must be understood, however, that this is nothing whatever to do with the weather or with thunderstorms. Those storms are due to quite different causes.



A diagram by Mr. S. Chapman showing how the stream of particles thrown out by spots on the Sun's disc describe a series of arcs in their passage across Space to the Earth. They come like water falling from a revolving hose.



The great hydrogen flames thrown up from a sunspot photographed on four successive days at the Mount Wilson Observatory in America.



A diagram showing the close relationship between the number of sunspots, as indicated by the bottom line, and magnetic activity on the Earth, as shown by the upper line, during the period 1835 to 1930.

The magnetic storms do not occur very often—sometimes only twice a year, and rarely more than five times. They last for about two days, and all the observatories that are watching see their magnetic needles moving violently at the same time.

At such times displays of the Aurora are impressive, but there are other indications that something is happening. Electric cables are disturbed and radio and radio-telephony are subject to considerable interference.

Now, these things generally happen when there are large sunspots near the centre of the Sun's disc, and so men of science, putting the various facts together, have come to the conclusion that there is a close connection between the spots on the Sun and the various magnetic and electrical manifestations which affect the Earth.

Charts have been made indicating by a zigzag line the periods when sunspots are large and frequent, and this line corresponds with remarkable closeness to a similar line representing periods of magnetic disturbance on the Earth. The two lines are given on this page.

Mr. J. Bartels, of the Department of Terrestrial Magnetism in the Carnegie Institution of Washington, estimated that the particles thrown out by the sunspots take about one and a half days to reach the Earth, and in their passage describe a series of arcs not unlike water falling off a revolving garden hose.

"Between the first impact," he says, "and the time the Earth is completely enveloped by the storm less than one minute elapses, which explains the practically simultaneous beginning of many magnetic storms. The detailed movements of the particles are very complicated, especially near the Earth, where they are deflected by the Earth's magnetic forces."

We can understand that these particles from the Sun should affect radio transmission because the radio waves travel in the same upper layers of the atmosphere in which the magnetic variations are produced.

In these outer regions, which are, of course, most sensitive to cosmic influences, there is direct evidence of the influence of solar variations.

How activity in the upper atmosphere affects our weather is explained in the articles in pages 801 and 1026.

THE IDENTITY OF THE LEVER AND PULLEY

It is always interesting when looking at a complicated machine, to see how it is made up of simple devices such as levers, pulleys, wheels and axles, and so on. On this page we see how these mechanical devices are really identical in principle. We can prove it for ourselves by a series of simple experiments

We speak of the lever, the pulley and the wheel and axle as being separate mechanical powers, but the pulley and the wheel and axle are really only adaptations of the lever. They are indeed identical in principle, and the pictures given on this page show how this may be proved by a series of simple experiments.

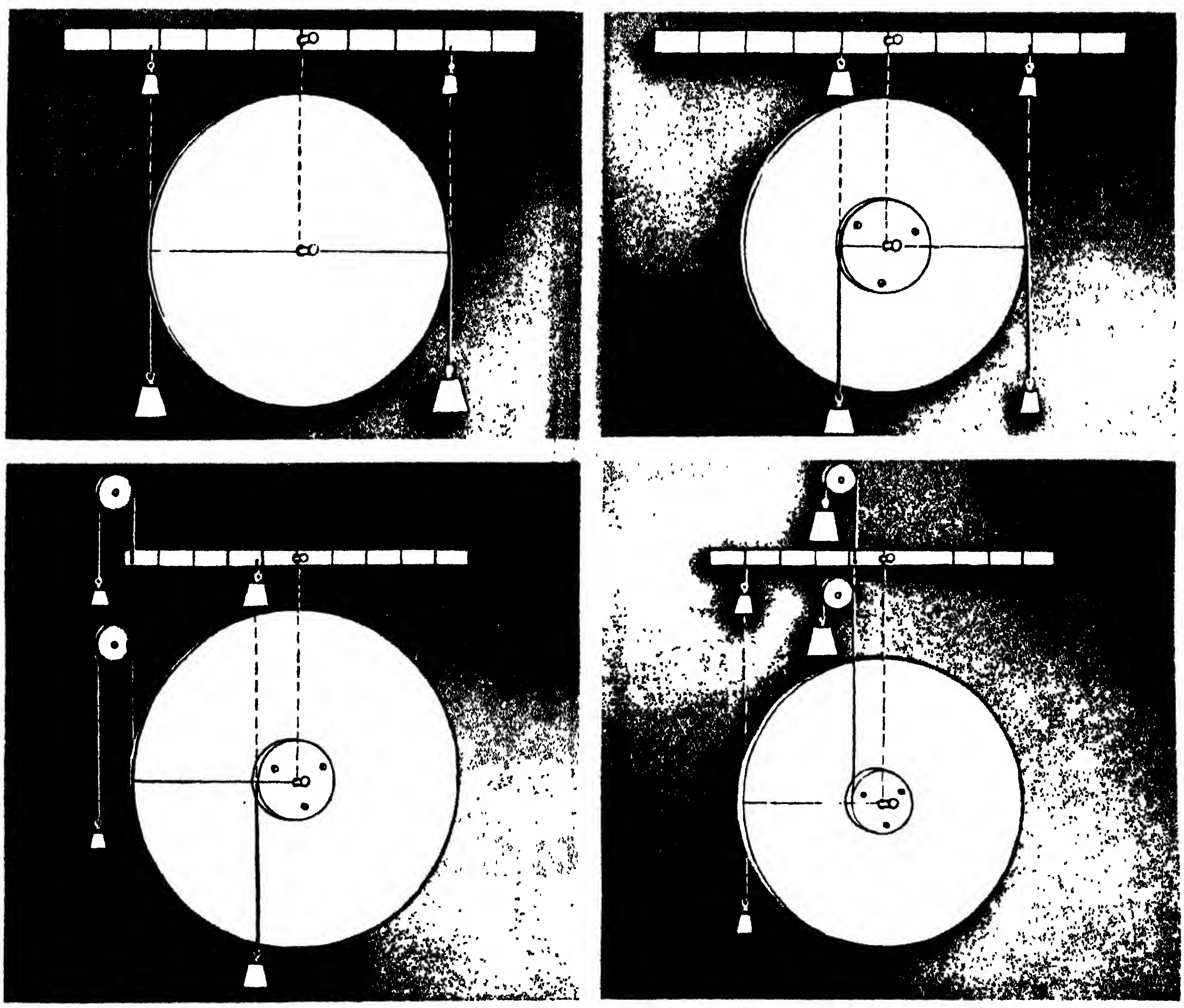
Seeing how modern machinery depends upon these elementary mechanical principles, it is well that we should thoroughly understand them. All machinery, indeed, no matter how complicated it may be, is really only an adaptation of simple and elementary principles.

All we need for the experiments is one or two strips of wood, such as boxwood rules and one or two wooden wheels with grooves round the rims. The first diagram explains itself, and shows clearly the identity of the pulley with the lever of the first order

The second experiment also shows clearly the similarity between a wheel and axle and a lever of the first order with unequal arms.

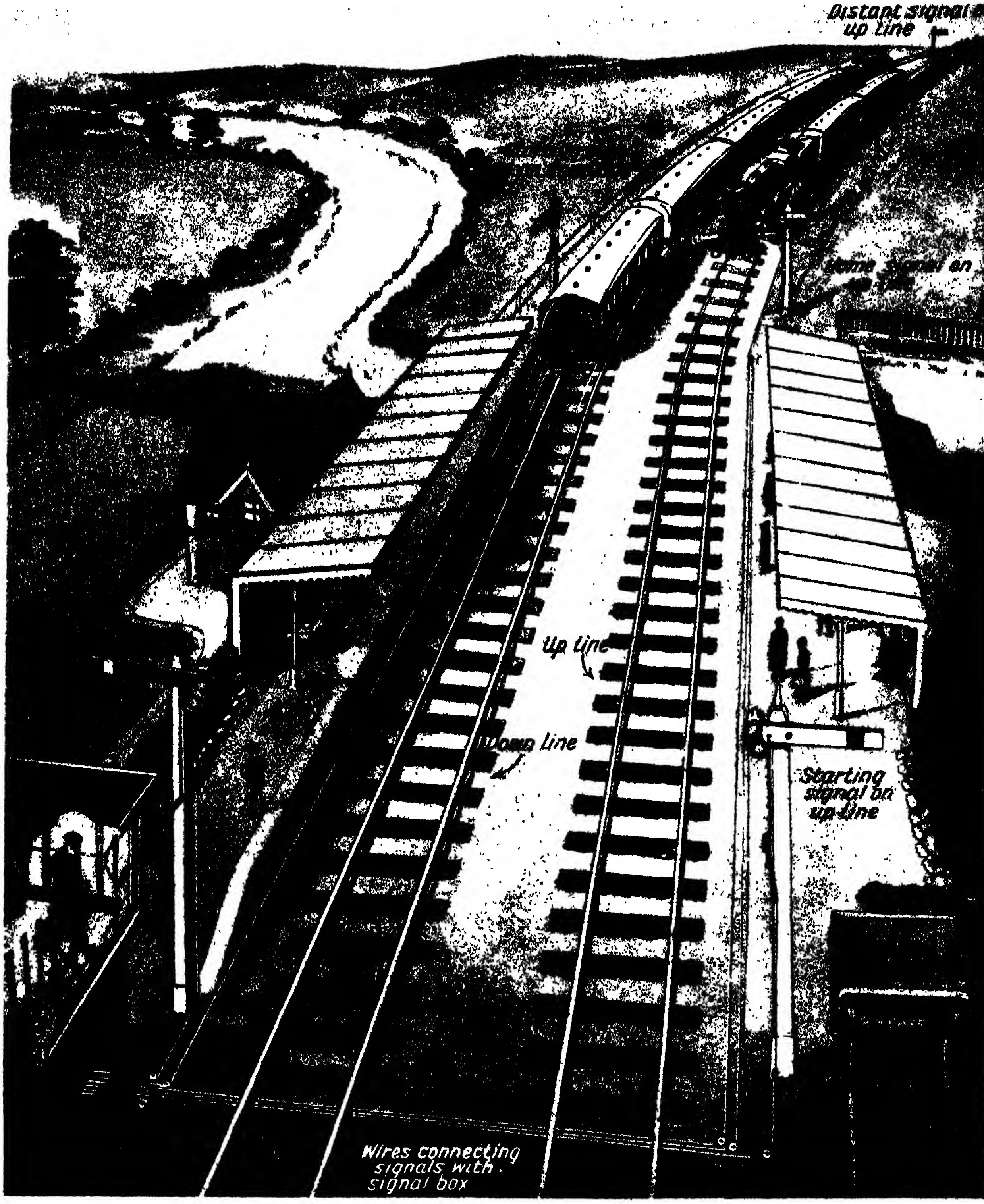
The last two diagrams show how the wheel and axle corresponds with levers of the second and third orders. If we have a number of weights it will be very interesting to experiment with different weights and find the proportions between the weights that exactly balance.

Of course, we must see to it that each lathe and wheel can rotate freely round a nail or screw. In the wheel and axle the small wheel can be glued or screwed to the large one. The wheels and lathes need not be large.



The upper left-hand picture shows the identity of the pulley with the lever of the first order. The three succeeding pictures make clear the identity of the wheel and axle with levers of the first, second, and third orders, the levers in these cases having unequal arms

HOW THE SIGNALS ON THE RAILWAY WORK



The pictures on these pages explain the ordinary system of signals which is in use on British Railways. There are three main signals, the distant, home and starting. In the left-hand picture a non-stop express has just passed the station on the down line. In this case the distant signal does not come into the picture, but all three signals were down, meaning that the line was clear for the train to pass. The train having gone, the home signal has just been put up to stop the next train till the line ahead is clear. When the express has passed the starting signal, that will also be put up, and then all three signals on the down line will be up to stop any train following till the express is clear of the next section of the track. The railway line is divided into sections, each with its own set of signals, and is therefore known as the "block system," because with the signals up a train is kept in one block or section of track. Now we come to the up line. In the left-hand picture a train is approaching. The distant signal is at the horizontal position, indicating that the home signal is ordering the train to stop. The distant signal is merely an advance warning to the driver of the home signal's position. It is generally 800 yards from the home signal, but if the track is downhill it is 1,000 yards or more away,

AND MAKE IT SAFE FOR TRAINS TO TRAVEL

and if it is uphill the distance may be reduced to 600 yards. This is to give the driver time to slow down and pull up his train when he comes to the home signal. In the right-hand picture the train, having stopped at the station, is ready to go on. The starting signal has been lowered, permitting the train to proceed. It is shown just starting. After it has left the station all three signals will be placed at the horizontal to stop any other train from going on till this train has cleared the next section. All stop signals have square-ended arms, but the distant signal, to distinguish it from the others, has a V-shaped notch at the end. These signals used on British Railways are known as semaphores. Each arm is generally about five feet long and one foot broad. In America and on the Continent the arm, instead of being lowered to show "clear," is raised. A distant signal is never lowered to "clear" unless the home signal ahead, controlled by the same signal-box, is also at "clear." If an express driver sees a distant signal at "clear," he can assume that he is free to run through the station. In the signal-box the signals are worked by a row of levers placed in what is known as a locking-frame. The points and signals are interlocked, that is if a signalman has moved a lever and opened a pair of points, the home and distant signals are thereby placed at "danger." Automatic signalling is described on pages 1106, 1107 and 1162.

MACHINERY USED IN THE TIMBER INDUSTRY

Machinery is used in every industry nowadays with a consequent vast saving of human labour, which is one of the causes of unemployment in the modern world. Here we see a 60-horse-power caterpillar tractor at work taking 1,250 logs of 165 pounds each from the forest in Ontario to the pulping station where they are turned into pulp for paper. The use of the tractor instead of horse labour saves about threepence on each log, a tremendous economy when the number of logs dealt with is considered

Here is what is described as the biggest wood pile in the world. It is at Damascus in Virginia, and the wood is piled up or removed as required by an ingenious machine known as a wood-piler, which does the work of many men using a crane in the old-fashioned way, and does it in a twentieth of the time that would otherwise be necessary. The saving in cost, as can be supposed, is very great

WONDERS OF LAND & WATER

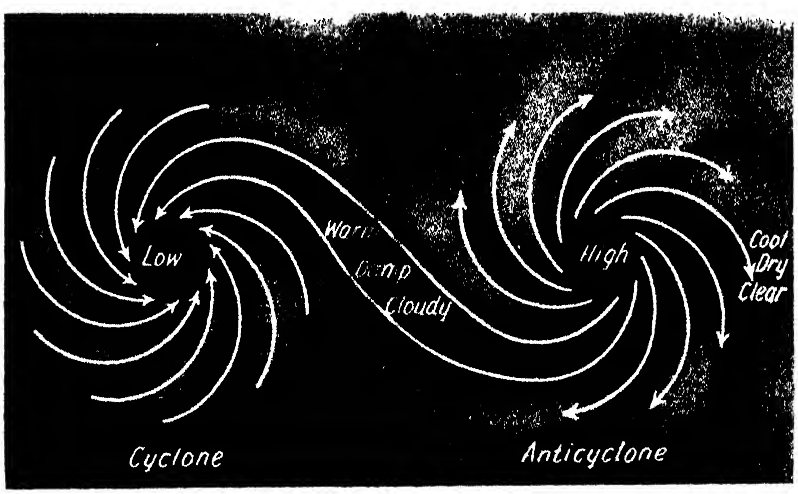
HOW THE WEATHER IS MADE

A great deal of our welfare and happiness depends upon the weather. Bad weather means poor crops and dear food, and a rainy summer spoils our holiday. It is important, therefore, that we should understand something about the causes that make the weather and here the matter is explained so that all can understand

THE weather is very fickle. We never know for more than a day or so what the weather will be like, and succeeding years are very different from one another. In one year we may have a warm March and a cold, blustery April, whereas in the following year March may bring us frost and snow, while April may be a month of sunshine and blue skies.

What is it that makes the weather, and why can we not look ahead and know what the weather will be, so as to arrange our outings and holidays for the fine spells?

In the old days, before education was compulsory, there were some people who, when they were arranging an outing, used to look in Old Moore's Almanac to see what the weather was going to be. Of course, sometimes the almanac was correct by chance, but more often it was wrong. No one can prophesy the weather weeks ahead, not even the scientist who gives his life up to the study of meteorology.



The cyclones and anticyclones which make our weather follow one another in more or less quick succession. If they always followed along the same line then this picture-diagram would represent the directions of the winds and we should be able to foretell the weather with far more accuracy than we do now. We are supposed to be looking down on the cyclone and anticyclone from above

The Cyclones

Let us look at the causes of bad and good weather. We often read in the weather report about cyclones and anticyclones. Sometimes the cyclones are called depressions or simply "lows," because the mercury stands low in the barometer tube owing to the pressure of the atmosphere being light. Anticyclones, on the other hand, are called "highs," because the mercury in the barometer stands high owing to the pressure of the atmosphere being greater. Perhaps we know in a general way that a cyclone means wet, windy weather, while an anticyclone means sunny and calm weather. But if we are to understand the weather we must know rather more than this.

When ordinary people use the word "cyclone," which comes from the Greek word for a circle, they generally think of one of those violent storms that occur in America and elsewhere, in which the wind whirls round in a circle or spiral at such a rate as to unroof houses, blow trains off the railway line, and sometimes even carry away buildings.

Such a storm is a cyclone, but it is not quite the same thing as the cyclones which we get in Great Britain, although there is a similarity. The violent cyclones so common in the United States and in West Africa are perhaps better called tornadoes, as that word is not likely to get confused with the "cyclone" referred to in the British weather report.

A Tornado's Tremendous Force

The tornado, which is a whirlwind or mass of air rotating round an axis, may be 200 feet in height, but its breadth is often not more than 10 feet, and while the rotating wind sometimes whirls round at as much as 500 miles an hour, the whole revolving spiral is carried forward across country frequently at a speed of anything up to 40 miles an hour. Nothing can resist the tremendous force of a tornado, and everything in its way is mown down as by a scythe.

Now the cyclones that our weather reports speak of, which pass across Great Britain, are also rotating winds. They not only swirl round spirally, but are also carried forward as they rotate. These cyclones, however, are not whirling at anything like the terrific rate of the smaller tornado.

They generally advance from the south-west, starting far out in the Atlantic, and passing across the British Isles towards the north-east. Occasionally, however, they may travel in the opposite direction, and while the wind of the cyclone is whirling round with a circular or spiral motion, the whole thing may not make any forward progress at all, but remain stationary over a certain area for a time. These cyclones, when they advance, generally move forward at a rate of from 20 to 50 miles an hour, but sometimes they attain a speed of 70 or 80 miles an hour, and then we experience a gale or hurricane.

The cyclone rotates not in the same direction as the hands of a clock move, but in the opposite direction, and it is sometimes so big as to cover the whole of England. It may last for two or three days, and during that time we have almost continuous bad weather. The diameter of the cyclone will vary from 2,000 to 3,000 miles, and its form is sometimes oval.

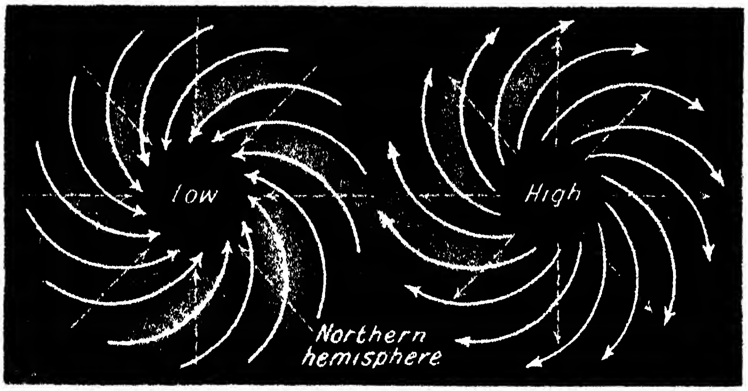
Warning Signs

We may know when a cyclone is approaching by the closeness of the air, the muggy feeling, the fact that drains begin to smell, and that people subject to rheumatism feel pains in their joints. Cirro-stratus and cirrus clouds appear in the sky, and very often there is mist. Then come showers, or drizzling rain, and the wind begins to blow in gusts.

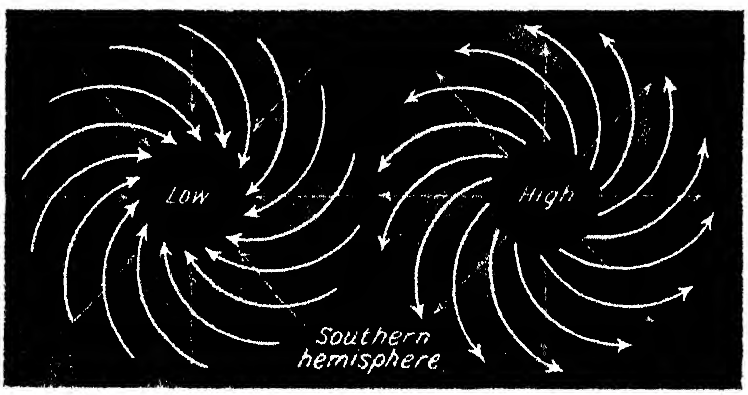
All this time the barometer has been falling, for when the air is damp it is less dense than when it is dry, because the vapour of water is only about three-fifths the density of air. This means that there is less weight of air pressing on the short arm of the mercury barometer, and so the mercury there can rise, which causes it to fall in the long tube of the barometer against which the scale is placed.

After a time the barometer ceases to fall, and then there will probably be a short interval of fine weather. This means that we are now in the centre of the cyclone, round which the winds are whirling. Then follow squally showers, and the clouds now take on the cumulus form, that is, they appear as great woolly masses. This is the type of cloud that follows a cyclone, just as cirrus or cirro-stratus clouds precede it.

Sometimes a secondary cyclone may occur at the outside edge of the main cyclone, and this is spoken of by meteorologists as a "secondary depression." The wind generally blows in gusts, and the motion of the secondary depression is generally parallel to that of the main or primary cyclone. Often when a weather forecast proves false this is due to the sudden formation of a secondary depression.



This picture-diagram shows how the winds blow during a cyclone and an anti-cyclone in the Northern hemisphere. The curved arrows show the actual directions and the straight arrows how the winds would blow if they were not deflected by the Earth's rotation. In the centre of a cyclone the barometer registers low pressure, and in the centre of an anti-cyclone high pressure



Here we see how the winds blow during a cyclone and anticyclone in the Southern hemisphere. The rotation of the Earth deflects the winds differently in the two hemispheres, as can be understood if we think of the matter while rotating a small globe

Secondary Cyclones

When we get a bad spell lasting for a week or more it is usually due to the fact that the primary cyclone has been followed by a succession of secondary depressions. There may even be a succession of primary cyclones, lasting for several weeks, and these are often followed by what is known as an anticyclone.

This, as its name implies, is the opposite of a cyclone. The pressure of the air is greatest at its centre, but the readings of the barometer do not vary so much between the centre and the outside as in the case of the cyclone. The result is that there is but little wind movement and the centre of the anticyclone is generally a calm.

What wind there is blows outwards from the centre, and not inwards as is the case with the cyclone, and the movement is in the same direction as the hands of a clock. The breezes of an anticyclone are gentle and the weather accompanying it is sunny. The desert regions of the world are regions of anticyclones and sometimes many years elapse without such places receiving any rain at all.

The anticyclones are usually much larger than cyclones, and sometimes cover not only the whole of the British Isles but the Continent as well, and extend over half the ocean. The whole anticyclone moves along generally in a direction from east to west, though sometimes it is from north-west to south-east. In summer time the anticyclone brings us dry warm weather, but in winter dull weather with fogs, as there is little wind to blow the fogs away when they form.

Now we see from all this that it is during an anticyclone that we have our spells of fine weather, but these are spoilt by a cyclone charging into the anticyclone at from 20 to 50 miles an hour.

It is the cyclone, therefore, which really makes our weather, but that fact does not carry us very far, for we naturally want to know what makes the cyclone. The causes of anticyclones are unknown, but men of science who study the weather have found out something which explains to some extent the cause of cyclones.

Cyclones on the Earth are caused by cyclones on the Sun, though on the great luminary 93 million miles away a cyclone is something quite different from what it is on the Earth. We call a solar cyclone by the misleading name of "sunspot."

Long ago, before telescopes had reached the perfection that they have now, astronomers watching the Sun's face noticed that certain dark spots appeared and travelled across the disc. They had no idea what caused these, but they spoke of them as sunspots. In more recent years the true nature of a sunspot has been discovered, and we read something about it on pages 366 to 368.

A sunspot is really a vast cyclone in the incandescent vapour which envelopes the Sun, a kind of whirlpool of fire mist.

Astronomers further discovered that the solar cyclones change their latitude. When they are at their minimum they appear in high altitudes, far from the Sun's equator. Then as they approach the maximum they get nearer and nearer to the solar equator. Now the meteorologists or weather students have found that cyclones on the Earth take a more northerly course in some years and a more southerly course in others.

Bringing the discoveries of the astronomers and the meteorologists together, we learn that the direction of the Earth's cyclones corresponds to some extent with the direction of the Sun's cyclones.

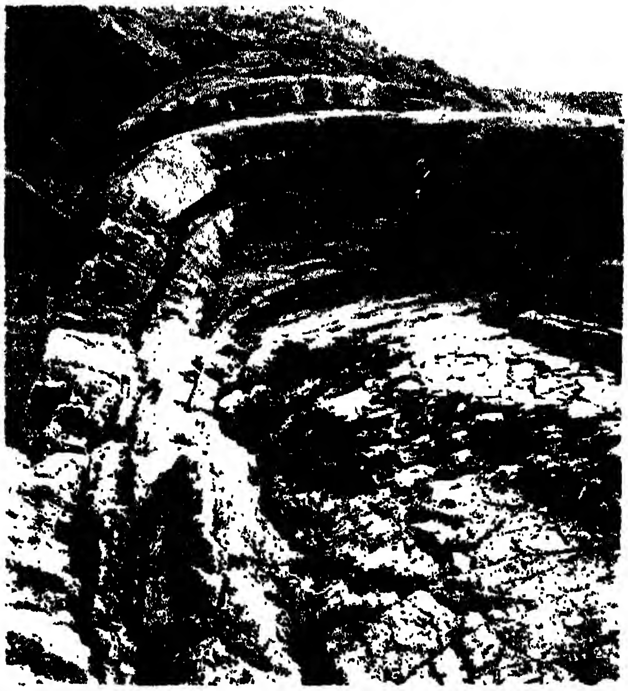
Lunar Influence

Owing, however, to the fact that the Earth's surface is so varied, part of it being sea, part mountain, part level country, and so on, the Earth's cyclones are deflected a good deal out of their course. Further, the pull of the Moon, which causes the tides, also has something to do with the direction in which a cyclone moves over the Earth's surface.

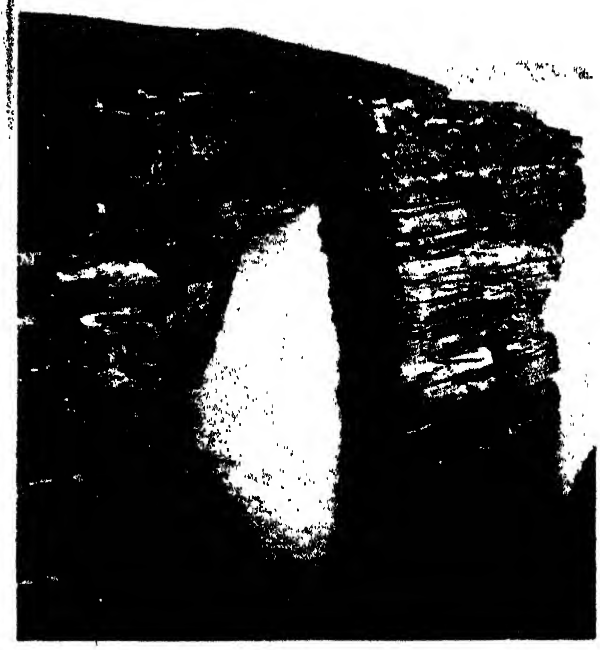
It is clear, therefore, that while we are only just beginning to know how our weather is made, we know at any rate that it is due to what happens on the Sun. The weather is made by the cyclone, the cyclone is made by the sunspot, and if we want to carry this house-that-Jack-built story still further we must turn to page 368 and learn what causes sunspots or solar cyclones.

It should be explained that the description given in these pages refers to cyclones and anticyclones in the Northern hemisphere. In the Southern hemisphere the facts are similar but the direction in which the wind blows is, owing to the Earth's rotation, slightly different.

SOME VARIED ROCK FORMS IN GREAT BRITAIN

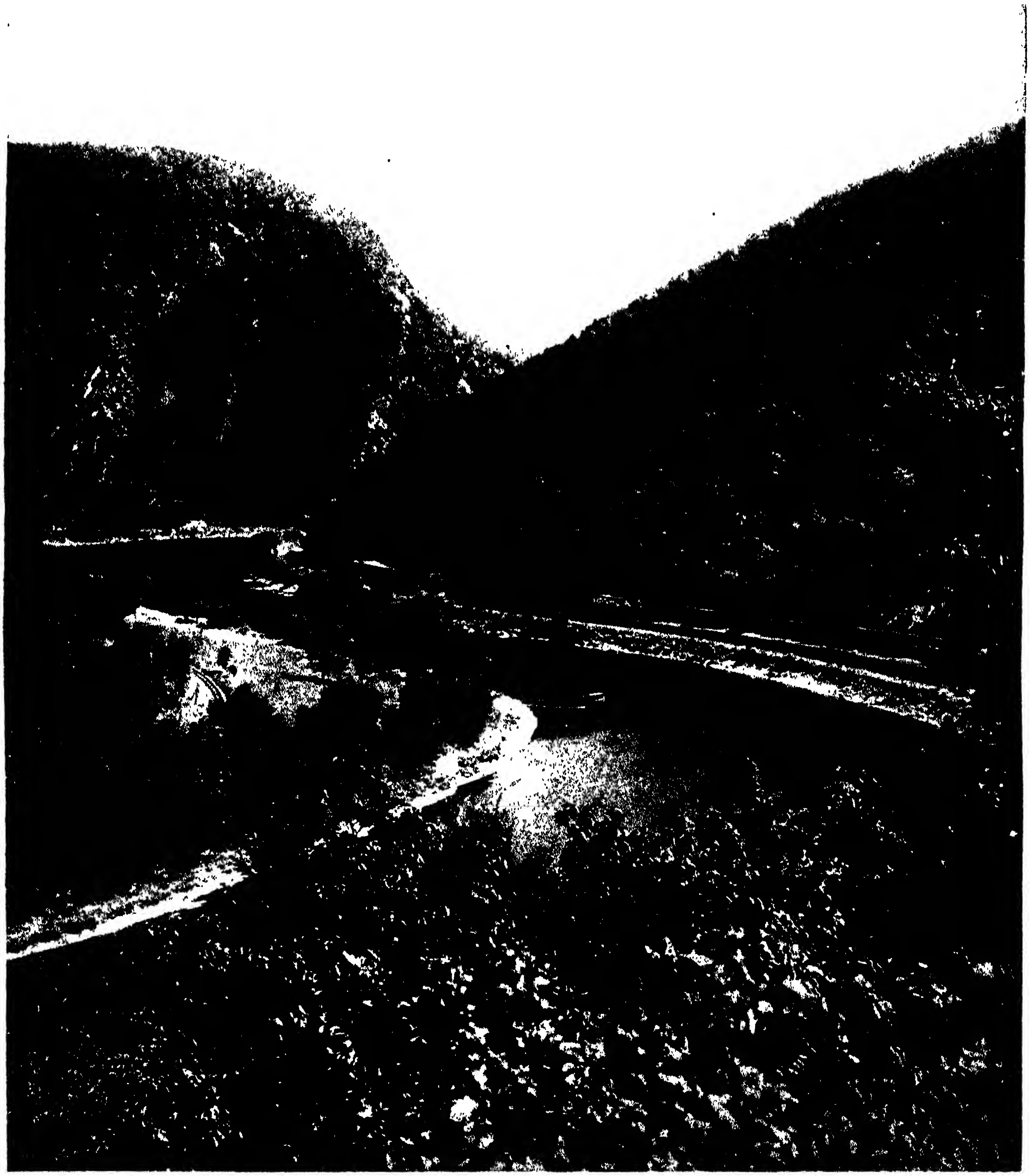


An immense variety of rock forms can be seen in different parts of the British Isles, and some of these are shown in these Geological Survey photographs, which are reproduced by permission of the Controller of His Majesty's Stationery Office. On the left we see well-bedded limestones with shales and mudstones crossed by an overthrust, the whole steeply inclined. This formation is at Harness Slade in Pembroke, and shows stratification very clearly. The right-hand photograph, taken at Broad Haven Pembroke, shows a remarkable monoclinal fold—that is, a dip in a strata in one direction. There is a striking overthrust which enters the cliff in the background and the whole looks like an artificial sea wall. An overthrust is a fault or split in the strata and a moving of the rocks



Here on the left is a striking example of the way in which rocks have become contorted and folded by lateral pressure as the Earth's crust cooled and shrank. It shows layers of black slates and limestones on the island of Kerrera near Oban, and the way the folding has taken place can be seen by a simple experiment. Lay several layers of cloth on the table, spread a board on top, and then, with two books press the ends inward. The cloths will become folded and contorted like the strata in the photograph. In the right-hand photograph we see the "Needle" near Wick, in Caithness. This arch has been carved by the sea out of the solid red sandstone

THE FORESTS THAT HOLD THE SOIL ON THE HILLS



Forests and woods on mountain slopes and hillsides are of the greatest importance to mankind, for the roots of the trees hold together the soil and prevent it being washed away by the rains and floods that pour down the slopes. In many parts of Europe where men have cut down the trees and destroyed the forests the soil has been washed away and nothing but bare and barren rock remains. Not only does the destruction of the forests result in the loss of the soil on the slopes, but by removing all obstacles such as trees and the tangle of undergrowth it causes the water after the storms to pour down into the valleys as destructive torrents This photograph shows the well-wooded hills near Delaware in Pennsylvania. Here the soil is properly protected and held securely to the slopes

ROMANCE of BRITISH HISTORY

THE MUTINY OF THE BOUNTY

The mighty British Empire has been built up in many different ways. Some of it has been won by conquest, some by settlement and colonisation and some in other ways. But no part of the Empire has had such a strange origin as the little solitary fragment of land away out in the Pacific Ocean between Australia and South America, which is known as Pitcairn Island. Here is the strange and romantic story

WHEN Captain Cook visited the Society Islands in 1769 Sir Joseph Banks, the distinguished botanist who was with him, declared that the bread fruit tree which grew at Tahiti would be an excellent plant to introduce into the West Indies.

Seventeen years later some West Indian merchants asked the British Government to help in introducing the bread fruit tree into Jamaica, and it was arranged to send a ship out to the Society Islands especially equipped for carrying young plants across the seas. The ship selected was the *Bounty*, a small vessel of 215 tons with a complement of officers and men numbering 45, under the command of Lieutenant William Bligh of the Royal Navy.

Bligh had served for four years with Captain Cook as sailing master of the *Resolution*, and had already visited Tahiti and the adjacent islands.

Those were days of bullying in the navy, and Lieutenant Bligh, who afterwards became an admiral, seems to have been a bully of the first water. Even in later life, when he became Governor of New South Wales, his harsh exercise of authority towards military and civilian subordinates alike led to serious trouble. So unreasonable was his conduct on that occasion that he was deposed by a junior officer and imprisoned.

The officer was later tried by Court Martial and cashiered, but no other punishment was meted out to him, which suggests that there was reason for his action.

Trouble Begins Early

The ship was carefully fitted out at Deptford in the Thames, and a cabin on deck set apart for the preservation of the bread fruit plants. Lieutenant Bligh had a small cabin on one side and a place near the middle of the ship to eat in. On each side were the berths of the mates and midshipmen together with the arms chest. The cabin of the master of the ship in which the key of the arms chest was always kept was opposite to Lieutenant Bligh's.

The route was to be round Cape Horn, and the ship was victualled for an eighteen months' voyage. On board there were four 4-pounder guns and ten swivels with a quantity of ammunition.

Trouble began before the ship sailed. Bligh was made purser as well as commander, and being of a very suspicious turn of mind he accused his men, while the ship was fitting, of stealing the stores. As far as can be ascertained there was no justification for the charge, and naturally the men were very resentful. The commander, who was of an irritable and passionate disposition, became exceedingly unpopular from the start.

The *Bounty* left the Thames on October 9th, 1787, and anchored at Spithead on November 4th. It was some weeks before a start could be made owing to weather conditions, but at last on December 23rd, with a strong easterly wind blowing, the *Bounty* sailed away. The wind increased, and during the next day or two a good deal of damage was done to the ship and its boats. At Teneriffe a stop was made to take in water and wine, together with some beef, but the

Lieutenant Bligh, who commanded the *Bounty*. From the painting by Sir Joshua Reynolds

meat proved so bad that most of it was thrown overboard by the men.

On January 14th, after leaving Teneriffe, Lieutenant Bligh told the ship's company that as it was doubtful whether the vessel would be able to round Cape Horn so late in the season and the length of the voyage was therefore uncertain, it would be necessary to be very careful of the provisions, particularly of bread. He then ordered the allowance of bread to be reduced to two-thirds, but the arrangement was agreed to quite cheerfully and grog was served out in place of the reserved bread.

The weather now became fine, and the commander ordered that the cheeses which were on board should be brought up on deck to be aired. When the casks were opened two cheeses were missing, and thereupon Bligh declared angrily that they had been stolen.

The cooper pointed out that the cask had been opened while the ship was in the Thames and that Lieutenant Bligh himself had ordered the cheeses to be taken on shore. Bligh thereupon ordered the allowance of cheese to the men to be stopped till the deficiency caused by the loss had been made up. Then, turning to the cooper, he declared that he would have him flogged if he said anything more about it.

Later on butter was issued and the seamen refused to accept it, alleging that if they took the butter without the cheese it would be a tacit acknowledgement of the theft. At this point an able-bodied seaman declared that he himself had carried the cheeses to Lieutenant Bligh's house together with a cask of vinegar and other things. Naturally the whole episode of the cheeses made relations still worse between the commander and his men.

Pumpkin Instead of Bread

When the ship approached the Equator a number of pumpkins which had been taken on board at Teneriffe began to spoil, so to make use of them quickly they were issued to the ship's company in lieu of bread, one pound of pumpkin being given in place of two pounds of bread. This the crew refused to accept, and when the commander was informed he went on deck in a towering rage, called all hands together and told Mr. Samuel, the ship's clerk, to summon the first man of every mess and let him see who would dare to refuse it or anything else that he should order to be served.

"I will make you eat grass or anything I can catch before I've done with you," he exclaimed. At this, all the men, including the officers, accepted the pumpkin ration.

After a time rations began to get short, and it was then stated that the casks containing the beef and pork had never been weighed and were short The crew went to the master and asked him to inquire into the matter, and if the weight really proved to be short to procure them redress

The master, John Fryer, carried the complaint to Lieutenant Bligh, who at once ordered all hands aft and informed them that everything relative to the provisions was transacted by his orders They need, therefore, make no complaints for they would obtain no redress He was the fittest judge, he said, of what was right or wrong Then he concluded by stating that he would flog severely the first man who should dare to make any complaint in future

Seamen in those days must have been very long-suffering We are told that the men of the *Bounty* determined to bear their hardships with patience, and neither murmur nor complain afterwards

The officers, however were not so easily satisfied, and frequently murmured about the small food allowance As each cask was broached the best pieces were taken out for the commander's table while they were compelled to take their chance of what remained in common with the men

Lieutenant Bligh and his companions being cast adrift from the *Bounty* by the mutineers
From the painting by R. Dodd

On March 23rd the *Bounty* reached Tierra del Fuego, and the men were in high spirits at the prospect of rounding Cape Horn On that day a sheep died and Lieutenant Bligh ordered it to be issued in lieu of the day's allowance of pork and peas, declaring that it would make a delicious meal It weighed fifty pounds and was divided up, but most of the men threw their portions overboard Some dried shark was then supplied in its place for Sunday dinner, but this proved to be nothing but skin and bone

The weather now became bad, with hail, rain, sleet and snow following one another in heavy squalls The cold was intense, and the heavy rolling of the ship and the terrible conditions, with short rations, began to tell on the health of the men They were perpetually wet, and rations were so short that it was no uncommon thing, when the boiled wheat and barley were served out of a morning, for four men in the mess to draw lots for the breakfast, one eating the whole supply and the others going without

There were frequent quarrels about the food allowance, and in some of these men were injured A number fell sick The weather became worse, and Lieutenant Bligh then declared that as the passage round Cape Horn was impracticable that year, he intended bearing away for the Cape of Good Hope

After an uneventful voyage, the *Bounty* reached the Cape of Good Hope, and anchored at Table Bay on May 25th Fresh provisions with bread and wine, were naturally very welcome to both officers and crew The ship was overhauled and re-fitted, the rigging and sails being repaired and the hull caulked

The *Bounty* then sailed for Tasmania and after a boisterous passage reached that land Here wood and fresh water were obtained, and large quantities of fish caught

Lieutenant Bligh seems to have become more ill-tempered and bullying than ever He accused some of his officers of inattention to duty, which greatly annoyed them, and he also put the carpenter in confinement for some trivial offence Matters were not improved when scurvy made its appearance, and the men became ill and weak

Quarrelling on Board

The voyage was continued, but during the passage Lieutenant Bligh and his messmates, the master and the surgeon, fell out and separated, each taking his part of the food away and retiring to live in his own cabin They seldom spoke to one another except when duty required Other quarrels also occurred

At last, on October 25th, 1788, the *Bounty* arrived at Tahiti, having covered 27,086 miles at the rate of 108 miles for each 24 hours of sailing a respectable rate for those days Lieutenant Bligh gave his men instructions not to mention to the natives that Captain Cook was dead No one was to use firearms except in defence of his life

A supply of fresh food, including plenty of coconuts and vegetables, proved a great boon and the sick began to recover It was found, however, that bread fruit plants were scarce The native chiefs inquired after the various Englishmen whom they had known during Captain Cook's visits, and they mentioned that they had heard a report that Cook had been killed, though apparently they knew nothing of the circumstances

At first provisions were plentiful, but after a time, when the supply fell off, Lieutenant Bligh, according to James Morrison, the boatswain's mate, seized everything, taking all for his own property and only serving a pound per man per day as the ship's allowance to the crew

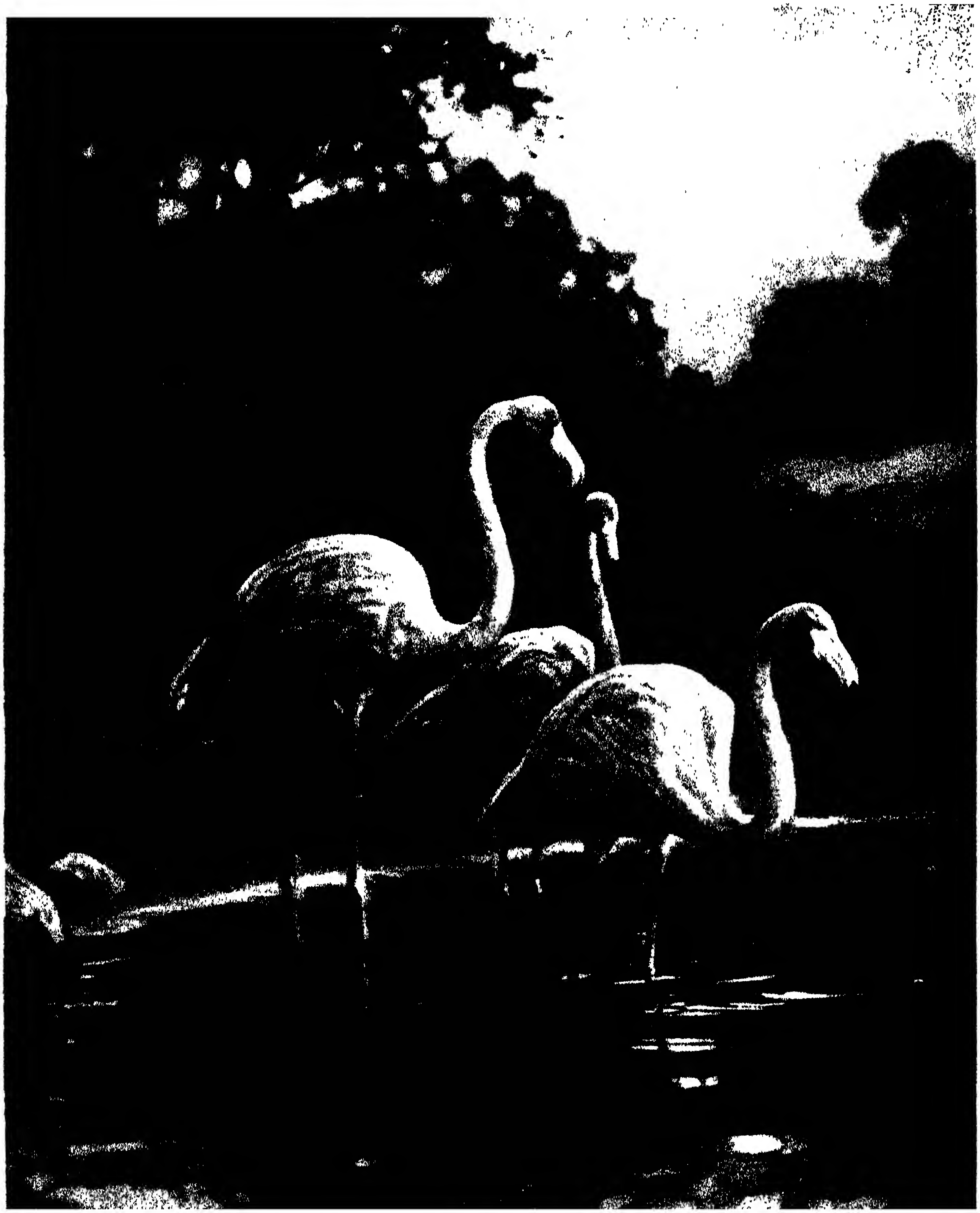
He also seized some hogs which had been given to the master, although he had more than forty of his own on board When the master pointed out that the pigs were his property, Lieutenant Bligh replied that everything belonged to the commander as soon as it came on board, that he would take nine-tenths of any man's property, and let all beware of saying anything to the contrary

The collection of bread fruit plants began, and over a thousand were collected and taken to the ship

One amusing incident occurred during the stay at Tahiti The ship's barber had taken with him from London a painted head such as hairdressers used to have in their shops to show the different fashions of hairdressing It was dressed up to look like a woman, and the natives crowded on board to see what they supposed was an Englishwoman They actually asked Lieutenant Bligh if it was his wife. Presents were given to the dummy, but at last they discovered the hoax.

On January 5th, 1789, the small cutter of the *Bounty* was found to be missing, and Lieutenant Bligh at once mustered the ship's company, when it appeared that three of the crew were absent—Charles Churchill, the ship's corporal, and two seamen, William Musprat and John Millward. Examination of the ship was made, and it was

THE "FLAME-BIRD" IN ITS FIERY PLUMAGE



It is the flame-colour of its roseate feathers that gives the flamingo its romantic-sounding name. Primarily a wading bird, with large webbed feet, it can also swim, but because of the disproportionate length of its legs, it is only a moderate flyer. When fully grown the adult bird is often over six feet tall. Standing in several feet of water, the flamingo feeds in a curious manner : because of the sharply down-curved shape of its bill it has to bend its long neck until its head is upside down ; it then stirs the mud with its feet and scoops up and sifts it with its bill for the shellfish and water plants that form its food ; it raises its neck in order to swallow, then bends again for the next mouthful. The bird flourishes in captivity and there are specimens in most large zoos. See also in page 1185

To face page 1177

found that they had taken with them eight weapons and a quantity of ammunition.

Lieutenant Bligh went on shore and discovered that the boat was at a place called Matavai, some distance away, and that the deserters had departed in a sailing canoe for another island. The chiefs, at Bligh's request, went after the deserters, and seized them and bound them, but the men prevailed upon the natives, by promises of returning peaceably to the ship, to let them loose.

As soon as they were free they obtained possession of the firearms, and then escaped to a place some miles away. Some natives took the cutter back to the ship, but Bligh told the chiefs that he must have the deserters before he left Tahiti

A Rough Way with Deserters

Hearing that they were at a place five miles away, Bligh went after them, and when he found them hiding in a house called upon them to surrender. They did so and were carried back prisoners to the ship, when Churchill was given two dozen lashes and the other deserters four dozen each.

A midshipman, Thomas Hayward, was accused of being asleep on his watch at the time the men got away, and he was put in irons for a month and threatened with a flogging. Never was there a greater flogger than Lieutenant Bligh. Natives and Europeans alike all came under the lash. Flogging, indeed, was his remedy for everything

It is necessary that we should have a knowledge of all this preliminary history of the *Bounty*, in order that we may understand what followed The men had now remained so long at Tahiti that they were beginning to get enervated by the more or less easy life, and so Lieutenant Bligh prepared to sail for the West Indies.

On April 4th the *Bounty* bade farewell to the Society Islands, carrying with it a supply of pigs, vegetables, fowls, plantains and yams. At the Friendly Isles, where the *Bounty* called, the natives proved troublesome and tried to steal casks and other articles. However, a supply of yams and coconuts with wood and water was taken on board, and on April 26th the *Bounty* set sail once more.

In the afternoon of the following day Bligh missed some coconuts which were piled between the guns, and said that they had been stolen and that this must have been done with the knowledge and connivance of the officers. All were called up and questioned, but they declared to a man that they had not seen anyone touch them, to which Bligh replied rudely, "Then you have taken them yourselves."

He ordered William Elphinstone, the master's mate, to go down and bring up every coconut in the ship, which he did. There were large quantities, as the sailors had made considerable purchases on their own account. Bligh then questioned each officer as to the number of nuts he had bought, and going up to Fletcher Christian, asked him to state the number in his possession

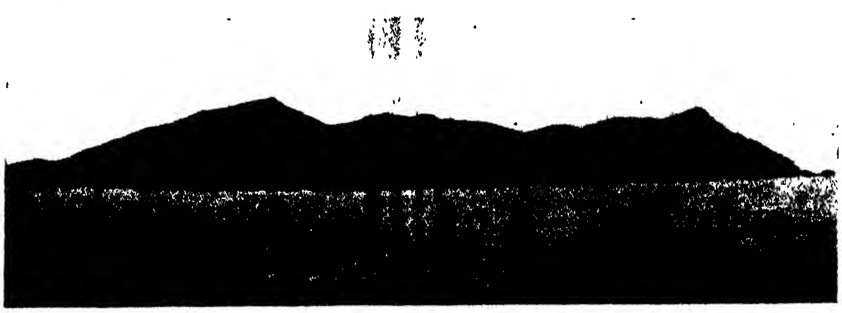
"I really don't know, sir," replied Christian, "but I hope you do not think me so mean as to be guilty of stealing yours."

"Yes," said Bligh, "you hound, I do think so. You must have stolen them from me or you could have given a better account of them. You rascals, you are all thieves alike and combine with the men to rob me. You will steal my yams next. I will flog you and make you jump overboard before we reach Endeavour Straits."

Fletcher Christian, it must be explained, was no rough seaman from the dregs of society He was a Cumberland man with relatives of some distinction in the Isle of Man His brother was professor of law at Cambridge University and Chief Justice of Ely. Fletcher was 24 years old and had twice before sailed on voyages with Lieutenant Bligh

Amazing Behaviour

The commander's remarks to him were interlarded with offensive swear words, and it seems an amazing way for a commander of the British Navy to speak to his officers. In these days he would be cashiered. Even for the eighteenth century, Lieutenant Bligh's attitude to his officers and men was exceptional



Pitcairn Island as it appears rising out of the sea

After abusing the officers, he called Mr. Samuel, the clerk, and ordered him to stop the grog and give only half a pound of yams to each person on the next day. All the coconuts were then, by Lieutenant Bligh's orders, carried aft, and he went below.

Some of the officers grumbled, but Fletcher Christian said nothing; he merely went into his cabin. In the evening Lieutenant Bligh sent Christian an invitation to take supper with him, but not unnaturally he declined, alleging in excuse that he was not well.

Now began a series of events that has become historic. Just before sunrise on the morning of the 28th Lieutenant Bligh was awakened by the sound of people entering his cabin. When he opened his eyes he saw Christian with the master-at-arms, Charles Churchill, the gunner's mate, John Mills, and an able seaman, Thomas Birkett, just about to seize him.

They tied his hands with cord behind his back, threatening him, so he declared, with instant death if he spoke or made the least noise Bligh tells us that he called out as loudly as he could, hoping that assistance would come, but the mutineers, for so they proved to be, had already secured the officers who were not of their party, by placing sentinels at their doors.

The Bully Bullied

Besides the four men in Lieutenant Bligh's cabin, there were three others at the door. Christian was carrying a cutlass and the others had muskets with fixed bayonets After his hands were tied Bligh was forced out of bed in his shirt. He asked the men the reason for this violence, and the only answer he received was an order to hold his tongue

Two midshipmen, George Stewart and Peter Heywood, had been awakened by the noise on deck, and they saw Matthew Thomson, an able seaman, standing at the door of their cabin with a drawn cutlass in his hand. Naturally they asked the reason for this strange behaviour, and the reply was: "Mr. Christian has taken the vessel and is going to carry Lieutenant Bligh as a prisoner to England."

Peter Heywood at once dressed himself and, going on deck, found that the mutiny was a real fact. Christian ordered the boatswain and the carpenter to hoist out the large cutter and, beckoning to Heywood, ordered him into the boat "What harm have I ever done you," asked Heywood, "that you should bear so hard upon me? I trust you will relent." In the end Peter Heywood remained on the *Bounty*, being accidentally left behind in the confusion.

According to his own account, Lieutenant Bligh tried to persuade the people near him not to persist in such acts of violence, but without effect.

The evidence afterwards given by all the other people on the ship contradicted Bligh's statement. Apparently he did nothing whatever to stay the mutiny, although he afterwards tried to throw the blame on young Heywood, suggesting that he should have raised a party and rescued his commander.

Of course, in the circumstances, this was quite impossible.

James Morrison, the boatswain's mate, in a journal which he left, says that he and the master and three or four seamen proposed to make attempts to re-take the ship, but that when this was suspected the master-at-arms and another mutineer told his own party to stand to their arms. As resistance seemed useless, Morrison thought it well to assist in getting out the launch, as others unconnected with the mutiny were doing. Christian forbade that any firearms should be given to the party in the boat, but William Purcell, the carpenter, was allowed to take his chest of tools.

The boat was soon so deeply laden as to be scarcely seven inches above the water's edge, and Lieutenant Bligh, seeing this, implored Christian to relent, saying, "I will pawn my honour, Mr. Christian. I will give my word never to think of this if you will desist. Consider my wife and family."

To this Christian replied, "No, Lieutenant Bligh. If you had any honour things would not have come to this extremity, and if you had any regard for your wife and family you should have thought of them before and not behaved so like a villain as you have done."

When the boatswain attempted to soften Christian, the latter replied, "No, it is too late, Mr. Cole. I have been in hell this fortnight past, and am determined to bear it no longer. You know that during the whole voyage I have been treated like a dog."

The mutineers, having forced such of the seamen as they meant to get rid of into the boat, Christian directed a dram of rum to be served to each of his own crew.

Bligh was meanwhile kept apart from everyone, Christian holding him by the cord and guarding him with a bayonet. Then Bligh's hands were released, and he was ordered into the boat. He was allowed to take his clothes, and Christian handed him a book of nautical tables and his own sextant, saying, "That book, sir, is sufficient for every purpose, and you know my sextant to be a good one."

Four cutlasses were then thrown into the boat, a few pieces of pork, and the launch was cast adrift, the armourer and carpenter calling out to Lieutenant Bligh to remember that they had no hand in the transaction.

It was now 8 o'clock in the morning, and the sea was calm and waveless with little wind. There were in the *Bounty's* launch beside the commander eighteen other persons, and there remained on the ship Fletcher Christian together with 24 others. Lieutenant Bligh ordered his men to row as fast as possible towards the Friendly Isles, which were 25 or 30 miles away.

And now we must leave him and his companions and see what happened on the *Bounty*.

The midshipmen wanted to go in the launch, but were detained because, as Churchill said, "If anything should happen to Mr. Christian, there would be no one else to depend upon for navigating the ship."

John Adams, the mutineer, who reformed and taught the Pitcairn islanders the practice of the Christian religion

Thursday October Christian, son of the mutineer, who was the first person to be born on Pitcairn Island

Fletcher Christian took command and directed the *Bounty's* course for Tahiti. All the bread fruit plants were pitched overboard. But things did not go well with the mutineers. Some who had not taken part in the mutiny endeavoured to form a plot to re take the ship, but the plot was detected. Christian, however, seems to have retained the respect of all those on board, and he was invariably addressed as "Mr. Christian."

The *Bounty* arrived at Matavai Bay in Tahiti on June 6th, 1789, 39 days after the outbreak of the mutiny, and the natives flocked on board and were delighted to see their old friends again, particularly Fletcher Christian. They had always disliked Lieutenant Bligh. They were, however, surprised to see the ship again so soon.

Bligh had formerly represented himself as a son of Captain Cook, and Christian now told the natives that the *Bounty* had met Captain Cook on another vessel, which took Bligh and certain of the others on board, and sent the *Bounty* back to Tahiti to collect live-stock and provisions. The simple islanders believed the story, and were only too willing to do anything for their friend Captain Cook.

Hogs, goats, and fowls, with dogs, cats, and a bull and cow, were sent on board, and Christian decided to sail for the island of Toobouai, at which he had called on his way, but had soon left, finding the natives apparently hostile.

When the *Bounty* sailed from Tahiti, there were on board, in addition to the mutineers, nine Tahitian men, twelve native women, and eight boys. At Toobouai, the natives proving more friendly, the party landed, and Christian marked out the site of a fort and dug a ditch 24 feet all round, taking part himself in the hard work with the other men.

But the natives soon grew hostile and there was some fighting, in which Christian and another man were severely wounded, while several natives were slain.

Those of the *Bounty's* people who had been innocent of any complicity in the mutiny now plotted to seize the largest boat left on the *Bounty*, which was a light cutter 20 feet long, and after provisioning this, to escape during the night. The plan was discovered and stopped.

Christian commanded that there should be no violence towards the islanders, but some of the mutineers resented this and began to take the property of the natives by force without any recompense. Christian, finding the mutineers were getting out of hand, assembled them and asked them to express their ideas as to the future.

The majority wished to return to Tahiti, and there separate. It was agreed, therefore, that the *Bounty* should go back to Tahiti, and those who went on shore should receive arms, ammunition, and a share of everything on board. The ship was to be left in charge of Fletcher Christian in a proper condition to go to sea with sails, tackle, and other necessaries.

But before they could sail there was further trouble with the natives in which sixty men and six women were killed. Three friendly natives went on board and sailed with the mutineers for Tahiti.

The ship was received with every mark of hospitality by the Tahitians, and the party that intended to remain went ashore, taking their goods with them. Christian and the others also went ashore, and then prepared to return to the ship.

Two young midshipmen, Stewart and Heywood, accompanied him to the beach, but he advised them to remain and go off at once on any ship of war that might appear and give themselves up to the commander "You are both innocent," he said "No harm can come to you, for you took no part in the mutiny"

Some of those who remained at Tahiti prepared to build a boat with which to sail to Java and thence find a passage to England, but Stewart and Heywood declined to have any part in this, preferring to wait for the arrival of a ship of war from England

Trouble, however, soon occurred The vessel was begun, and one day Matthew Thomson, an able seaman had a quarrel with the natives He then went away to another part of the island, and one day shot a man and his young child Heywood and the other English residents, except Churchill, expressed their sympathy with the widow, and cold-shouldered Thomson He and Churchill went off into the interior of the island, where they soon quarrelled, and Thomson shot Churchill He had so obviously become a desperado that the natives decided to kill him, and they did so

At Pitcairn Island

The work of building the small ship now proceeded, but after a time some gave up the work and went to other parts of the island, where they settled down.

By August 5th the ship was finished and launched. She was given the name of *Resolution*, and was fitted with sails made of matting A trial trip proved that the sails would never work, and so the long journey to Java had to be abandoned.

But what had happened meanwhile to the *Bounty?* With nine white men, six native men and twelve women, it had sailed away to try to find Pitcairn Island, a place that Fletcher Christian had heard about and considered likely to prove a suitable retreat on account of its loneliness.

His chart, however, gave the position wrongly, and it was found only with some difficulty. The *Bounty* sailed round the island and at last found a bend in the shore to which the name of Bounty Bay was given. The party landed and made a survey, after which Christian divided it into nine portions, retaining one for himself and distributing the remaining eight parts among his English companions.

Everything was taken from the *Bounty*, including planking from her sides and copper nails and bolts It was decided to destroy the ship and leave no trace which could lead to discovery What was left was set on fire and the remains finally sunk in 25 fathoms of water The day that saw the last of the *Bounty* was January 23rd, 1790

After this Fletcher Christian seems to have become morose and moody, but nevertheless kept the respect of his companions. For three years all went well, and then quarrels broke out between the Englishmen and the Tahitian men, who were treated with great harshness. At last the native men hatched a plot to kill all the Englishmen. They succeeded in killing five, including Christian

John Adams teaching the children on Pitcairn Island the lessons of the Bible which had been saved from the *Bounty*

Demoralisation now set in, and the remaining four Englishmen, feeling insecure, came to the terrible decision that they would destroy all the Tahitian men. This horrible plot they carried out. Then the Tahitian women plotted to kill all the Englishmen, but the plot was discovered. The quarrelling, however, went on.

Then one of the number, M'Koy, who in early life had been employed in a distillery in Scotland, succeeded in making an intoxicating spirit. He and another man drank much of this, and one day M'Koy, in a fit of delirium tremens, threw himself from the rocks and was killed.

The other man, Quintal, became very quarrelsome, and at last was so dangerous that the remaining Englishmen, Alexander Smith and Edward Young, determined to destroy him in order to preserve their own lives. They did so, and there now remained on Pitcairn Island only two of the Englishmen who had been on the *Bounty*.

And now a very strange thing happened. These men, who had taken part in plots and bloodshed, suddenly determined to change their evil lives and live virtuously. They had on the island a Bible and a Prayer Book which had been saved from the *Bounty* With these they established the practice of having regularly every day morning and evening prayer.

They studied these books and began to give regular instruction in religion to the women and children on the island. Young, being better educated, took the lead in this, but he was zealously assisted by Alexander Smith.

Then in 1800 Young died, and Smith now found himself the sole surviving man on the island, and the only guardian and teacher of a community of helpless women and children He changed his name to John Adams, possibly to indicate his change of life

Prayer Before Work

This change of life was quite genuine, and the little community on Pitcairn Island, which had grown out of such tragic circumstances, became an ideal Christian community Even the children entered into the spirit of this kind of life.

Before the islanders went out fishing or undertook any risky enterprise, they always met for prayer

So the community grew up Then, in September, 1808, an American ship, the *Topaz*, cruising in the Pacific, happened to notice smoke rising from a rocky island. It was Pitcairn, and great was the surprise, for no inhabitants were supposed to exist there. Soon a canoe was seen approaching the ship, and to the amazement of all on board they were hailed by the occupants in good English with offers of assistance.

An Englishman on board went ashore in the canoe, and there heard the wonderful story of what had happened to the mutineers of the *Bounty*. Later the captain of the American ship landed.

No further news of Pitcairn was received until 1814, when two British frigates, the *Briton* and the *Tagus*, called there. A number of people gathered on the shore among the rocks, and two launched canoes, paddling till they came alongside the *Briton*. Apparently those on board had not heard that the *Bounty* mutineers had reached Pitcairn. Judge of their astonishment, therefore, when a voice suddenly called out in plain English: "Won't you heave us a rope now?"

A rope was thrown out and a fine young man sprang on deck. "Who are

you?" asked the officers. "I am Thursday October Christian, son of Fletcher Christian, the mutineer, by a Tahitian mother, and the first person born on this island," was the reply. The youth was accompanied by another named Edward Young, who was the son of a midshipman of that name in the *Bounty*. He was eighteen years of age and Christian, whose names Thursday and October were taken from the day and month of his birth, was twenty-four.

The officers and men of the *Briton* were astonished at the deportment of the young men, at their stately bearing and natural easy manners. They were conducted over the ship, where the sight of a cow astonished and alarmed them. They seemed to think that it was a large goat or a horned sow. Although strangers to the most common mechanical contrivances and the useful arts of civilised life, they displayed great intelligence and appreciation of all they saw, inquiring constantly for further information.

The Last Mutineer

After the inspection of the ship, refreshments were set before them, and the astonishment of the crew was great when, before sitting down, the young men devoutly folded their hands and repeated a short grace, and at the conclusion of the meal repeated another. These, they said, in reply to questions, had been taught them by John Adams.

The officers of the ship visited the island and were conducted to the little village where Adams, his blind wife, and the whole community stood ready to receive them. The islanders were anxious to know if the strangers intended any harm to their beloved leader. When they understood that nothing but friendliness was felt, they assented to the officers being ducted to his house.

John Adams was just over 50, healthy and robust in appearance, but his countenance showed signs of age and wear, being furrowed with marks of anxious thought. At first he believed the visitors had come to arrest him for his part in the mutiny, but on being told that they had been perfectly ignorant of his existence on the island, he was greatly relieved.

There were altogether forty-six persons on the island, and all were strong, healthy, smiling, and showed unruffled good humour. The women were remarkable for their modesty. Adams frankly disclosed all the terrible circumstances which had occurred in the history of the mutineers, and while he declared that he had had no previous knowledge of the mutiny or in any way been accessory to it, he expressed great disapproval of Lieutenant Bligh's conduct towards his officers and men.

When asked if he would like to return to England, he answered, rather to the surprise of the officers, that he would. He declared that he was perfectly aware how deeply he was involved, and that by following the fortunes of Christian his life was forfeit, but even despite that it would give him great gratification to see his native land once more.

The captain thereupon offered to give him a passage with any members of his family he cared to take. Adams appeared pleased, but when he summoned his family and explained the matter to them, they were shocked.

The young Pitcairners seemed to think the cow was a large goat, or a horned sow

"Oh, sir," said his daughter to the captain, "do not take from me my best, my dearest friend." So pathetic was the scene and earnest the solicitations from all the community to Adams to remain on the island, that he decided not to go. "I never witnessed," said the captain, "a scene so utterly affecting or more replete with interest."

The Pitcairn islanders increased in numbers, and although there were many ups and downs it remained fairly prosperous, till at last the community became too large for the island.

In January, 1850, the sixtieth anniversary of the arrival of the mutineers was celebrated with great ceremony and rejoicing. One of the guns of the *Bounty* had been brought up from the sea bed where it had lain for more than half a century, and was fired. The Union Jack was hoisted, and a public dinner was held at which cheers were given for Queen Victoria and the British Government.

Two years later Rear-Admiral Fairfax Moresby, who had taken a great interest in Pitcairn, visited the island, and later a chaplain was sent out from England carrying portraits of Queen Victoria and Prince Albert. The island was recognised as a part of the British Empire, and one of the residents was appointed a magistrate and a system of laws tabulated following closely on the simple regulations that had been laid down by John Adams.

The people were grateful for the interest taken in them, and sent a letter home to Queen Victoria thanking her for officially recognising them.

But the problem of food became very pressing, and an offer having been made to carry the people from Pitcairn to Norfolk Island, 4,000 miles away, not far from Australia, this was, after some misgiving, accepted, and in May, 1855, the whole of the community, 194 in number, left Pitcairn Island in a British ship and was carried to Norfolk Island, which had long been used as a penal settlement.

The End of the Story

The people were to have a certain part of the island for their use, and on it were many well-built houses, with other large buildings for use as granaries, barns and stock houses, together with a chapel. A supply of stock and seeds was handed over to the Pitcairners, and for a time they seemed as if they would all settle down happily. But the climate was not so genial as that of Pitcairn, and in 1858 two families decided to return to their old island. They did so, and their descendants still live there, a little simple community of 140 people, administered as a British colony by a council of seven members, with a president and vice-president, who is the government secretary. They are subject to the control of the High Commissioner for the Western Pacific.

Norfolk Island, where the other descendants of the mutineers live, was handed over to the Australian Commonwealth in 1914, and its population is now about a thousand.

As to the rest of those who had been on the *Bounty*, their story may be briefly told. Bligh and his 18 companions who had been forced into the open launch 23 feet long made a marvellous voyage of 3,618 miles to Timor, an island near Java, and thence took ship for England. The Admiralty sent a warship out to Tahiti and captured the mutineers there. They were tried and three were hanged. Midshipman Heywood was found guilty but pardoned.

And that is the strange story of a little fragment of the great British Empire.

SMELL, THE OLDEST OF OUR SENSES

Men of science seem to think that smell is the oldest of our five senses ; that is in the development of man smell came before the senses of sight, hearing, feeling or taste. Whether this be so or not, it is undoubtedly a fact that in early days man used his sense of smell to a far greater extent than he does now. Indeed, at present, smell is the least developed of all our senses and the least used. Here we read many interesting facts about smell

It is impossible to live a normal life if we cannot see or hear, and without the sense of touch we are paralysed. Even to be without taste would raise all sorts of serious difficulties, but if we were deprived of smell while we should lose the pleasure of beautiful perfumes, we should hardly suffer at all.

How do we smell ? Most people would say by means of our noses, and that is perfectly true, but it is not all the nose that is used for smelling. Indeed, it is only a small part of it, and that the upper part.

Our nose is divided into two chambers, separated by a partition formed partly of bone and partly of cartilage The floor of the nose is formed by the hard palate at the top of the mouth, just as the floor of an upper room may form the ceiling of the room below, and the roof of the nose is a bone which is pierced by a number of small holes through which the nerves of smell, or olfactory nerves, as they are called, pass from the brain. This roof bone of the nose is called the cribriform plate, from the Latin word for a sieve, and it is the only thing which separates the cavity of the nose from the cavity of the skull which contains the brain.

At the sides of the nose there project scroll-like bones known as the upper, middle, and lower turbinates That word is really the same as turbine, and comes from a Latin word meaning a top The bones are so called because they are shaped very much like a spinning top or inverted cone

The whole of the inside surface of the nose is covered with a soft membrane or skin containing little vessels or ducts with tiny glands that produce moisture. But the membrane is not the same all over the nose, for that which lines the lower part has little thread-like vibrating filaments called cilia, and the nerve endings in this part of the membrane belong to the fifth cranial nerve. They are not used for smelling, but they get excited when anything irritating enters the nose. For example, if pepper gets up our nose or we take a sniff at a powerful smelling-salt bottle, these nerves get irritated and we sneeze or breathe out strongly, which is nature's way of removing anything that may be harmful to the nose.

Where the Smelling Nerves Are

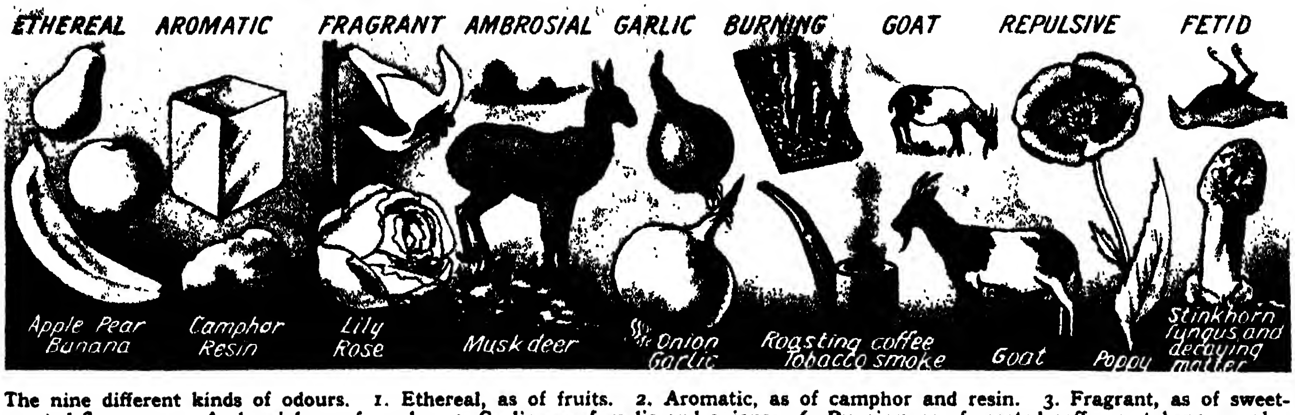
It is the upper part of the nose which is supplied with the smelling nerves. Here the membrane or lining does not contain the thread-like vibrating filaments or cilia of the lower part The cells of which it is composed are slender and rod-shaped, some having a large nucleus and others being thin throughout. Those with a nucleus are supposed to be the cells specially concerned in giving rise to the sensations of smell. The two kinds are found side by side. The branches of the olfactory nerve fibres are in contact with the cells, and carry the sensation of different odours to the brain.

As we can smell things sometimes at a considerable distance, it has been suggested from time to time that smell may be something in the nature of a wave motion, but this is not held by scientists to-day

The sense of smell is exercised when tiny particles either in the gaseous or solid form given off by substances enter the upper part of our nose and excite the little cells which are connected with the olfactory or smelling nerve fibres. There, some kind of chemical action takes place, and a message is passed on to the smelling part of the brain. The position of the cells is permanently in the mucous fluid, and so the particles of a substance have to be dissolved in this liquid before the smell nerve can be excited If the upper part of our nose becomes dry it is impossible to smell

When we breathe in the ordinary way air passes through our nose into the pharynx, a tunnel-like cavity, from the lower part of which it goes into the windpipe and thence to the lungs. It does not, however, enter the upper part of the nose where the smelling is done. A few of the little particles from a substance may, however, drift into the upper part and set up the sense of smell.

When we want to smell anything well we take a strong sniff and, by doing so, pass some of the air with a good many of the particles into the upper nose, and are thus able to excite our smelling nerves more actively. To excite the sense of smell strongly the particles, either gaseous or solid, coming from the substance we are smelling,



The nine different kinds of odours. 1. Ethereal, as of fruits. 2. Aromatic, as of camphor and resin. 3. Fragrant, as of sweet-scented flowers. 4. Ambrosial, as of musk. 5. Garlic, as of garlic and onions. 6. Burning, as of roasted coffee or tobacco smoke. 7. Goat, as of goat, cheese, or perspiration. 8. Repulsive, as of narcotic plants like poppy. 9. Nauseating, as of decaying meat or stinkhorn fungus. It is interesting to think of various kinds of odours and to try to class them under these heads

must be in rapid motion and sniffing strongly assists this.

The odorous particles may also enter the upper nose through the openings at the back entering from the mouth and pharynx That is why flavours which are perceived partly by taste and partly by smell, like that of the onion, are fully realised not during the act of swallowing, but afterwards, when the particles have had time to get to the nose from the mouth. When we have a cold and the upper nasal chamber is blocked by the swelling of the membrane, we are not only unable to smell properly but unable to taste properly, as so many flavours depend upon smell as well as taste. The picture on page 13 helps us to understand this.

odours, such as those of camphor, citron, and resin. 3. Fragrant or balsamic odours, such as those of pleasant flowers and perfumes. 4. Ambrosial odours, like those of amber and musk. 5. Garlic, as in onion, garlic, and sulphur compounds. 6. Burning odours, like those given by roasted coffee, baked bread, tobacco smoke, and so on. 7. Goat odours, like the smell arising from the animal named, from cheese and from perspiration. 8 Repulsive odours, like those given by narcotic plants. 9. Nauseating or fetid odours, like those given by certain plants and the products of putrefaction or decay. It is a very interesting list, and we could amuse ourselves by trying to put into

The sense of smell is easily tired. If we go on smelling a particular odour continuously for some time we cease to notice it, even if it is unpleasant, as when sitting in a hot room with a crowd of people. A stranger coming in would smell an unpleasant odour at once But while our sense of smell may be fatigued so as to be insensitive to one kind of odour, another kind will excite it at once.

But while our nerve of smelling is exhausted by the sensations set up by odours after a few minu es, the exhausted nerve will recover in the course of about a minute, after the odours have been removed. The power of smell is impaired by fever, and also by certain drugs.

An animal that has grown its nose long, developed fingers at the end and uses it for feeling and lifting as well as for smelling. This picture of a young elephant being captured is from the travel film, " Bring 'Em Back Alive "

If we hold our noses when eating food we are unable to get the full flavour, and similarly it is a good plan to hold the nose when taking nasty medicine, as some of the nastiness is then shut off from our senses.

We have seen on page 369 that all tastes can be divided into four classes—sweet, bitter, sour, and salt, but it is not so easy to classify smells in this simple way. They have been divided up into three classes—agreeable, disagreeable, and mixed, but that is not very satisfactory.

A German scientist, however, suggests that all odours may be divided into nine classes: 1. Ethereal odours, such as those given by fruits. 2 Aromatic

one or other of these classes the different smells which we recognise.

Some substances are extraordinarily penetrating to the sense of smell. Camphor can be perceived when it is diluted to the extent of one part in 400,000, musk one part in 8,000,000, and vanillin one part in 10,000,000. But even more penetrating is a chemical substance known as mercaptan, which has a very offensive garlic-like smell. If the 30,000th part of an ounce be divided up into 460 million parts we can smell one of these infinitesimally small parts. Some substances retain their power of exciting the sense of smell for a very long time. A grain of musk retains its scent for years.

In many animals the sense of smell is far more keenly developed than it is in man. Hounds track a fox or stag by scent. Bloodhounds follow a man by using their sense of smell. Even a dogfish in the water finds its prey by smell rather than by sight.

It is very interesting to watch a dog when it is following a trail. It keeps its nose close to the ground and, using the sense of smell instead of sight, follows the trail wherever it may lead.

When doctors as an experiment have filled the two nostrils with substances of different odours, some people have smelt both, some have smelt only one odour, and others the other.

HOW THE BANANA GROWS ON A TALL STEM

The banana is perhaps the most valuable food plant in the world. The fruit is very nourishing, whether eaten fresh or dried, and 4,000 pounds of bananas will grow on the same space of ground that is required to produce 99 pounds of potatoes or 33 pounds of wheat. The dried fruit ground up makes an excellent flour, and a beverage is also made from the banana. The leaves are used to thatch houses, and the fibre makes clothing, sacking and rope. The plant is often called "the maid of all work in the vegetable world." The stalk grows to a height of twenty or thirty feet, produces one big bunch of bananas, and then dies down. For distant markets bananas are gathered green, and are allowed to ripen after they have reached their destination. They travel in specially cooled boats and trains

JACK-OF-ALL-TRADES THAT FLIES AND HOVERS

1

Because it can fly forwards, backwards, or sideways, ascend or descend vertically or hover stationary over land or water, the helicopter has made easier a lot of tasks which otherwise would be very difficult indeed. As the illustrations on this page show, the helicopter has become a flying handyman to whom few odd jobs come amiss

6

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7

1. Bristol Sycamore helicopter lifting with a rope and winch a pilot whose aeroplane has crashed into the sea. 2. Pilot and rescuer are winched up to the helicopter's open door. 3. Sikorsky helicopter of the Sabena airlines drops in to deliver mail for a Belgian town. 4. Sycamore helicopter taking and transmitting television pictures of Bristol docks. 5. Sycamore helicopter being used as an aerial crane. 6. Another way to rescue "ditched" airmen: a Sikorsky helicopter uses a net to scoop a crashed pilot out of the sea. 7. A Bristol helicopter lifts a "casualty" from a ruined building during a Civil Defence exercise. 8. Hillier helicopter spraying insecticide over a Hampshire cornfield

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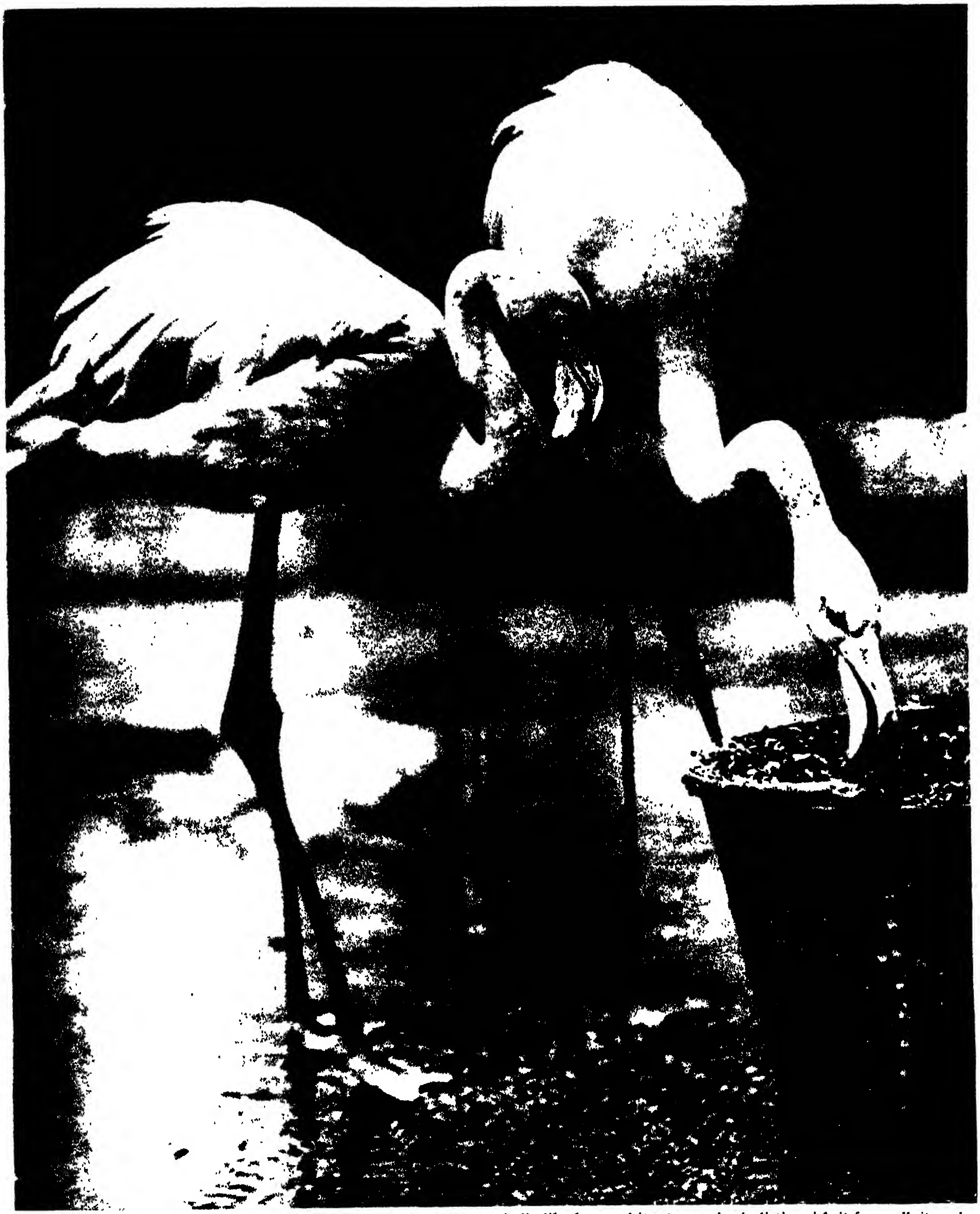
THE FLAMINGO WHICH IS FOUND IN WARM LANDS



We could never mistake the flamingo for any other bird. Its long spindle-like legs and its strange beak distinguish it from all its relations of the bird world. There are no flamingos in Australia, but otherwise they are found in most of the warmer regions of both hemispheres. The European flamingo, with its rosy white plumage and light scarlet wing coverts, is found as far south as the Cape of Good Hope Province and as far East as India and Ceylon. It sometimes travels as far north as the British Isles. Flocks of flamingos, numbering thousands, are seen by the lakes of North-Western India, and form one of the most marvellous sights in the world, especially when they suddenly fly up. The American flamingo is brighter coloured. Flamingos live on shell-fish and water-plants

LIFE ON THE EARTH 1,750,000 YEARS AGO

Life in the Oligocene Age shown in this picture was becoming in form much more like that which we see on the Earth to-day. There were many new forms of birds resembling present-day forms, such as the ancestors of our modern grebes and divers. There were geese of modern type, as seen at the top of the picture Among rhinoceros-like animals were the brontotherium, with two horns on the nose, as shown on the right, and the acerotherium (in the middle of the picture), more like the rhinoceros of to-day. Camel-like animals, seen at the bottom right, were developing, and also weasel forms, shown lower down. The pig-like animal at the bottom of the picture, called the hyopotamus, seems to have chewed the cud. On the left of this is the mesohippus, a small ancestor of the horse. Above this we see a group of hyracodon. This animal was about the size of a pony, but in form it was much nearer the rhinoceros, although more lightly built. In the water there were early whales, and among the vegetation of Europe were palm trees, olives and the ebony

LILLIPUTS OF THE SOLAR SYSTEM

Travelling round the Sun between the orbits of Mars and Jupiter are a thousand or more little worlds, some so small that they could be stood in Hyde Park, and the largest not too big to find standing room in the British Isles. We call them minor planets or planetoids. The old name was asteroid. Men of science cannot tell us how they originated. Some have thought they formed part of an exploded planet, though this is rather unlikely. Another theory is that they once formed a ring or rings like those of Saturn

THERE are far more members of the Sun's family of worlds than many people imagine. Of course, we all know of the giant members of the family, Saturn and Jupiter, of the middle-sized worlds, Uranus and Neptune, and the smaller planets, known as the Earth, Venus, Mars, Mercury and Pluto. Altogether there are nine of these planets and many of them have their satellites circling round them.

But in addition to these notable planets and their satellites there are hundreds of other members of the solar system, which travel round and round the Sun just as the Earth does.

They are generally spoken of as "asteroids," a very unfortunate term, for it means "formed like a star," and these bodies are not like stars at all They are really planets, though on a very small scale, and so a much better name is that which is now given to them by astronomers, namely "planetoids." Another name by which they are called is "minor planets," to distinguish them from the nine major or larger planets

These little worlds, all of them far smaller than our Moon, and some no bigger than small hills, circle round the Sun in orbits between Mars and Jupiter.

The first of them was not discovered till the opening night of the nineteenth century. Yet as far back as 1596 the great German astronomer Kepler had suggested that there must be some kind of a world travelling round the Sun between Mars and Jupiter. He had noticed the great gap which occurred between the orbits of those two planets, and predicted that one day another planet would be found circling round in this space.

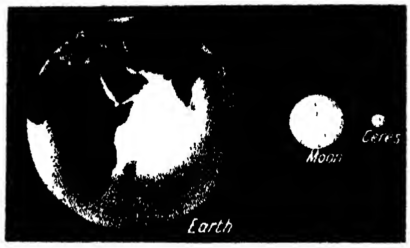
But nothing happened for two centuries, and then another great German astronomer, Johann Bode, who had made a study of the orbits of the planets, pointed out that the distances of the orbits from one another are not haphazard, but are in certain proportions

He suggested that if the series of numbers 0, 3, 6, 12, 24, 48 and 96 be taken and 4 added to each, making them 4, 7, 10, 16, 28, 52 and 100, these numbers, with the exception of the fifth, would represent with fair accuracy the relative distances of the orbits from one another. For the fifth orbit there was no planet, but Bode suggested that there should be a planet somewhere revolving between Mars and Jupiter This when set out was known as Bode's

Some of the minor planets are very small indeed. One of them is no more than 550 yards across, so that it could be placed in the middle of Hyde Park and still leave plenty of room all round for people to walk about. This picture of the planetoid and Hyde Park drawn to the same scale gives us some idea of the minor planet's size.

Law, and although the figures are not quite accurate, they are very near the truth.

On New Year's Day, 1801, an Italian astronomer named Piazzi, who was making a star map at Palermo in Sicily, noticed a little star in the constellation of the Bull which seemed to be moving slowly He watched it carefully and came to the conclusion that it must be either a planet or a far-off comet.



The Earth, the Moon and the planetoid Ceres drawn to the same scale

He said nothing to anybody, but watched this star for several weeks, and then believing that he had come upon an unknown planet, he published his great discovery But unfortunately at this point the new planet moved so close to the Sun that it vanished in the Sun's light. Further, Europe being at war, the letters sent by Piazzi to various German astronomers were delayed, and when men began to watch, the planet seemed to have been completely lost.

The idea of finding it again seemed almost hopeless, but a distinguished German mathematician, Carl Gauss, obtained all the facts he could from Piazzi and with great patience worked out the orbit of the new planet. It came in between the orbits of Mars and Jupiter, and then with the aid of his calculations the new planet was re-discovered exactly a year later, that is on New Year's Day, 1802, by another German astronomer, Heinrich Olbers


A photograph of part of the heavens showing three minor planets (each indicated by an X). By courtesy of Royal Astronomical Society

Here, said the men of science, was the missing planet, and it was named Ceres after the tutelary goddess of Sicily, where Piazzi worked. Then on March 8th of the same year another little planet was discovered wandering in the same region, and this was named Pallas. Two years later still another was found, and was named Juno, and three years later a fourth was seen and was called Vesta.

All these planets were moving round the Sun in orbits between Mars and Jupiter. The whole scientific world was agog with excitement, and astronomers everywhere were searching for still others. By the end of the century about a thousand had been found, and the discoveries succeeded one another so rapidly that at a meeting of the Royal Astronomical Society in 1909 a well-known astronomer suggested humorously that it should be made a legal offence to discover any more minor planets. Some of the astronomers were given the nickname of "planet hunters."

Still the discoveries go on, and of course, photography has enormously helped in the search. Nowadays a photographic plate is exposed for a certain period, the telescope being worked by clockwork to move with the stars, and then the plate is examined to see if there are any lines of light as well as points on it. If there are little lines they are caused by minor planets, which are moving or wandering in the sky. A photograph is reproduced on this page showing three minor planets among the stars.

The orbits of these minor planets are very much intertwined and entangled, but they all move round the Sun between the orbits of the planets Mars and Jupiter. Of course, it takes much patient calculation to know whether a minor planet that appears on a plate is a new one or an old one Quite a number of those that have been recorded have never been seen again since the year of their discovery.

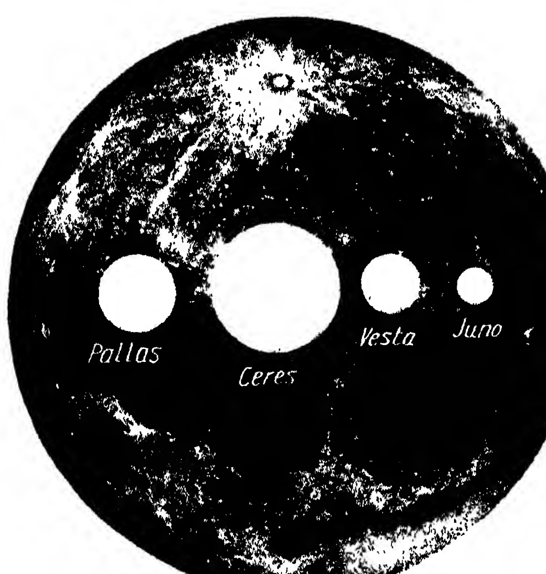
One of the most interesting of these minor planets is Eros, about which we read on Page 1030 Professor James Watson, of Michigan University, who himself discovered 29 planetoids, left money in his will for the planets discovered by him to be watched so that they might never be lost again

The minor planets vary much in size. The largest is Ceres, the first to be discovered, which is 485 miles in diameter, but the smallest is only 550 yards across. The whole of them rolled into one would not make a single planet as big as Mercury.

We do not know very much about the nature of these little worlds, but they are of very great importance to science, for by their aid the distance of the Sun from the Earth can be measured much more accurately than was possible before they were found.

Of course the force of gravitation on these little worlds is very small compared with that on our Earth.

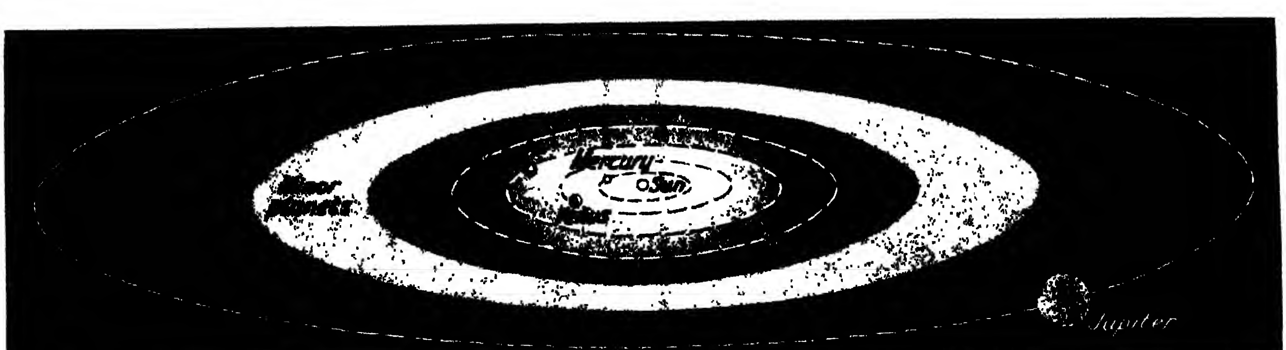
Sir Robert Ball has told us that a child on the Earth can throw a ball up 15 or 16 feet by giving it an initial speed upward of 30 feet per second. On a little planet 8 miles in diameter the ball would never return.



The Moon, with the four largest planetoids drawn to scale

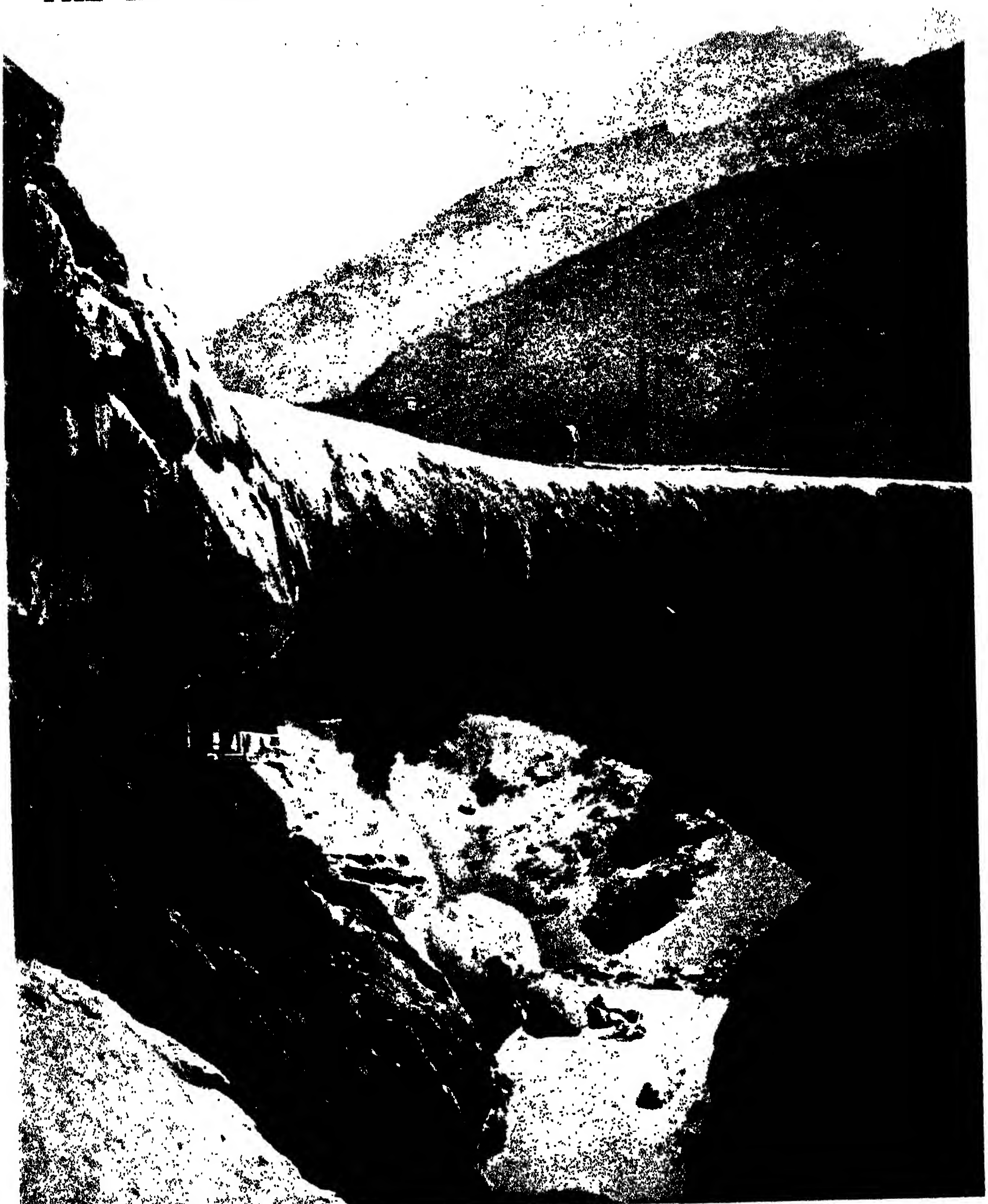
LITTLE WORLDS AND THEIR PATHS ROUND THE SUN

In this picture we see the four largest of the minor planets placed upon the map of the British Isles. The diameter of Ceres, the largest, is 485 miles, or considerably less than a quarter that of the Moon. Pallas, the next in size, is 304 miles across, Vesta 243 miles, and Juno 118 miles. It will thus be seen that Ceres, if dumped down on the British Isles, would reach from Berwick-upon-Tweed to Land's End. In mass or weight it would take 5,800 bodies like Ceres to make up one Earth. An eleven-stone man would weigh only half a stone on Ceres, and an object would descend only 8½ inches in the first second of its fall, as compared with 16 feet on the Earth. If a rifle bullet were shot from Ceres it would go off into Space and never return



Here we see how the minor planets, of which over a thousand have been discovered, circle round the Sun between the orbits of Mars and Jupiter. They do not, however, move round in the same plane, but their orbits are so interlaced that it has been said that if they were made of metal so as to form rings they could all be lifted up together by lifting one of them

THE IMPRESSIVE NATURAL BRIDGE OF ARGENTINA



Here is one of the most massive natural bridges in the world. It is to be seen spanning the Mendoza River which rises on the eastern flank of Aconcagua, the great volcano in the Andes 22,860 feet high. The bridge, sculptured out of the solid rock, is known as the Bridge of the Inca, and was at one time supposed to have been the work of the ancient inhabitants of these parts. But it is now known to be wholly a product of nature and to have been sculptured by the swiftly flowing waters of the river aided by the power of the Sun and wind. The scenery all round for miles is very majestic, the towering mountains forming a wonderful background to the bridge

NATURE AS A GREAT BRIDGE-BUILDER

Natural bridges as striking as any bridge made by the skill of man are to be seen in many parts of the world. In some cases they are of imposing dimensions and form a most impressive feature of the landscape. Here we read something about these natural bridges and the way in which they have been formed

The sculpturing of the rocks by Nature produces many fantastic forms, and perhaps nowhere are there so many varieties as on the American continent, both North and South. Vast chasms are carved out of the solid rock by rivers like the Colorado, the canyons of which, in some places, are a mile deep ; and wind and sand sculpture also provide many remarkable forms.

In the Garden of the Gods, in Colorado, there are 500 acres covered with rocky towers and spires that look against the skyline as though they were the tops of cathedrals built by the hand of man. An example of this kind of natural sculpture is to be seen in the photograph taken in Bryce Canyon given on page 754.

But of all these interesting geological forms none is more striking or remarkable than the great natural bridges that have been carved out and stand up so imposingly often hundreds of feet above the river or ground below.

America seems to be the great land of natural bridges. The most famous is that near Lexington in Virginia, which is 200 feet high, but there are many not only far higher than this, but of much more imposing proportions. The examples given on this page and the previous page will give some idea of how majestic these rocky formations may be.

All natural bridges are not formed in the same way. Some have been formed by earthquakes, the rock underneath having been shaken away, leaving a mass suspended.

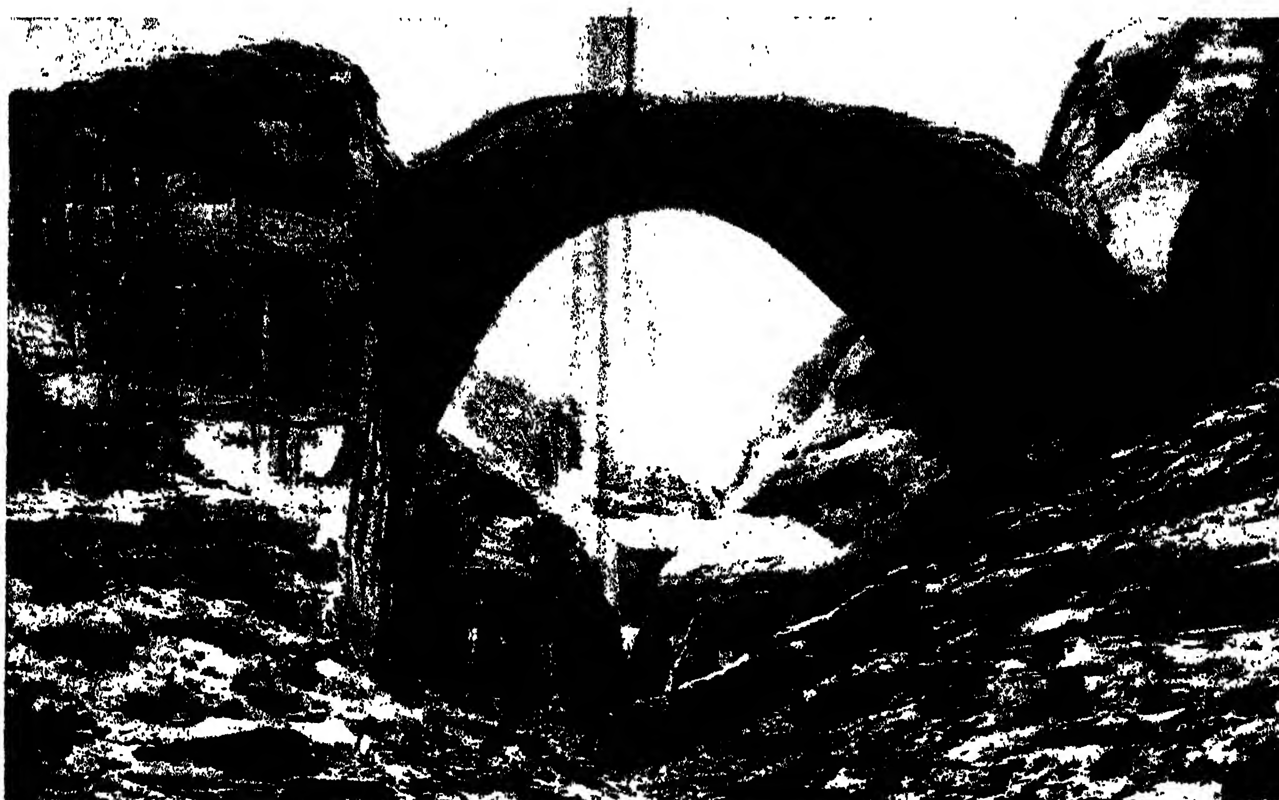
Other natural bridges have resulted from disintegration by water and wind, and the falling away of cliffs and rocks through the cracking and breaking up of the strata. A layer of harder rock above is left in position, and so we have a natural bridge.

But the most common way in which these bridges are formed is by the work of an underground river passing through limestone caverns. The cavern is made by the water that percolates through the soil above, dissolving the carbonate of lime.

The waters meet underground and form a subterranean river. This perhaps flows down to a lower cave and wears away a new and lower bed for itself. Then part of the cave roof falls in, so that the river is open to the sky, but another part of the roof is left suspended, and this forms a natural bridge.

In the course of time the river itself may be diverted, but not until it has worn away its bed so that this is two or three hundred feet below the bridge.

It is perhaps not at all surprising that where these formations exist among primitive and ignorant peoples they are regarded as of supernatural origin.



A marvellous natural bridge of rock 300 feet high in San Juan County, Utah. It is, from its shape, called the Rainbow National Bridge

HOW THE PEAT BOGS ARE FORMED

It is fortunate for the people of Ireland and the Highlands of Scotland that both those parts of the British Isles have extensive peat bogs to provide them with fuel, for neither Ireland nor the North of Scotland have coal deposits.

What exactly is peat and how does it differ from coal? Peat, like coal, is made up of the remains of plants, and the peat bogs if left alone would one day become coal. Experiments have been carried out which show that under a pressure of 6,000 atmospheres, that is, 88,200 pounds or nearly 40 tons to the square inch, peat can be converted into a hard, black substance which has the appearance of coal, burns like it, and shows few traces of vegetable structure.

But while it is true in a sense to say that peat is coal in an early stage of the natural process of manufacture, it is of much more recent formation. In fact, peat is constantly being made in these days. It is produced only in the colder temperate regions of the world, as in hot countries the process of decay of vegetable matter is too rapid for the formation of peat.

Just how the peat is produced is explained and illustrated on the next page. The sphagnum or peat moss grows over a lake and as it dies sinks to the bottom till what was once a lake becomes a spongy mass of decayed vegetation mixed with earth.

Peat retains its moisture so tenaciously that even after it is dried at a temperature of 100 degrees Centigrade, that is at boiling point, there is still a large proportion of water which cannot be driven off. The only way to dry it properly is to chop it up into small pieces so as to expose a very large area to the heat.

When dried, Irish peat has about 60 per cent. carbon, 32 per cent. oxygen, and 6 per cent. hydrogen.

The rate of growth of peat bogs varies greatly, but how rapidly peat may be formed is shown by a case in Scotland. In 1651 an ancient pine forest occupied a level tract of land among the hills in Ross-shire. The trees were dead and in such a condition as to be easily blown down by the wind.

Fifteen years later every vestige of a tree had disappeared, and the site had become a spongy bog, green in colour, into which a man would sink up to his armpits. Before 1699 the tract had become firm enough to be walked upon and to yield good peat for fuel.

The same thing happens elsewhere. In the valley of the Somme, in France, for instance, three feet of peat are formed in from thirty to forty years. On a moor in Hanover, a layer of peat nearly six feet deep was formed in forty years. On the other hand in Denmark it took from 250 to 300 years to form a layer of peat ten feet thick.

The rate of growth and formation depends upon many factors, such as climate, slope, soil and drainage. The Irish peat bogs are probably of great antiquity.

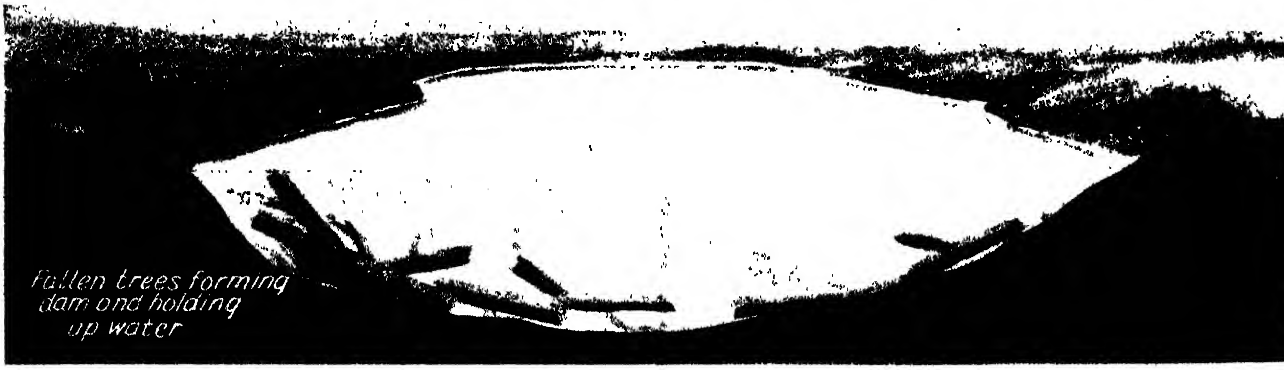
Peat possesses great antiseptic powers because of its chemical composition, and ancient animal remains buried in the bogs are often well preserved. In Ireland, for example, remains of the extinct Irish elk have been found in the peat bogs. Human weapons, tools, and armaments are also often dug out of peat bogs.

Tree trunks are frequently found in peat, not only in the lower layers but midway in a bed. Probably the overturning of trees has assisted in impeding drainage and so has contributed to the production of the conditions which promote the formation of peat. There must be water in order that the bog mosses of which peat is composed may be able to thrive.

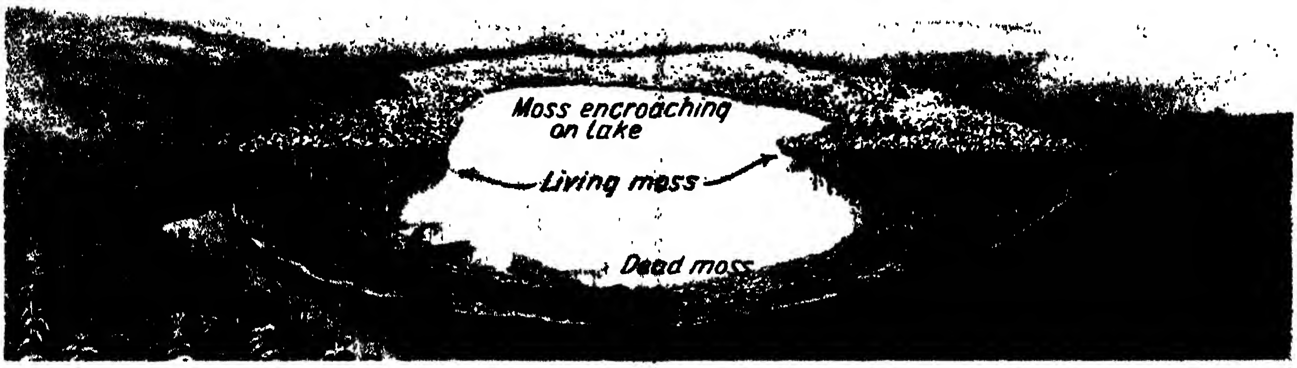
Peat can be converted into charcoal, and if the peat is compressed beforehand it is superior in density to wood charcoal. It can then be used in place of coke, but so far the conversion of peat into coke has not proved a paying proposition. Various valuable substances like ammonia, oils, gas and tar can also be obtained from peat, but the process is too costly to pay. Peat has been much used for horses' bedding and on account of its antiseptic properties it has been used for treating wounds.

Cutting peat for fuel from a great peat bog in the Irish Republic. The use of peat for domestic fires has always been encouraged in Ireland.

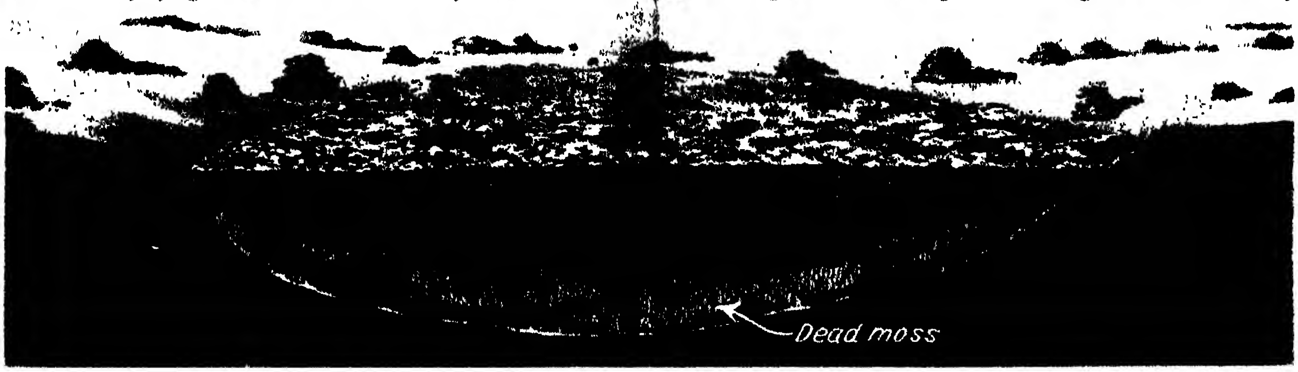
THE STRANGE STORY OF A PEAT BOG



Peat bogs are found in many parts of Europe, and one-seventh of the area of Ireland consists of peat bogs. The pictures on this page show how these bogs are formed. At some time in the past an area has become covered with water, possibly owing to the damming up of a small stream by fallen trees. More and more water has accumulated, until at last a lake has been formed, as shown here



The wet conditions are ideal for the spread of the sphagnum or peat mosses, which always thrive in places where there is plenty of water. These mosses continue to grow and branch year after year, and gradually they spread out over the lake, while the stems below are constantly dying. Farther and farther they reach out into the lake, the vegetation increasing till the margin becomes a swamp



At last the whole lake is covered with a tangled mass, and the moss gets thicker and thicker, the dead plants and stems gradually filling up the lake till it becomes a spongy mass of vegetation, living and dead. In course of time it becomes so thick that it can be walked across, and the decaying vegetable matter, mixed with soil blown upon the bog, enables the seeds of other plants to take root

In the course of years—it may be thirty or forty, or it may be a century or two—what was once a lake has become a peat bog anything from six to forty feet deep. The peat is cut and dried, but even when dried it contains a great deal of moisture. It forms a useful fuel where coal and wood are scarce, for it contains about sixty per cent. of carbon. The antiseptic powers of peat preserve animal remains

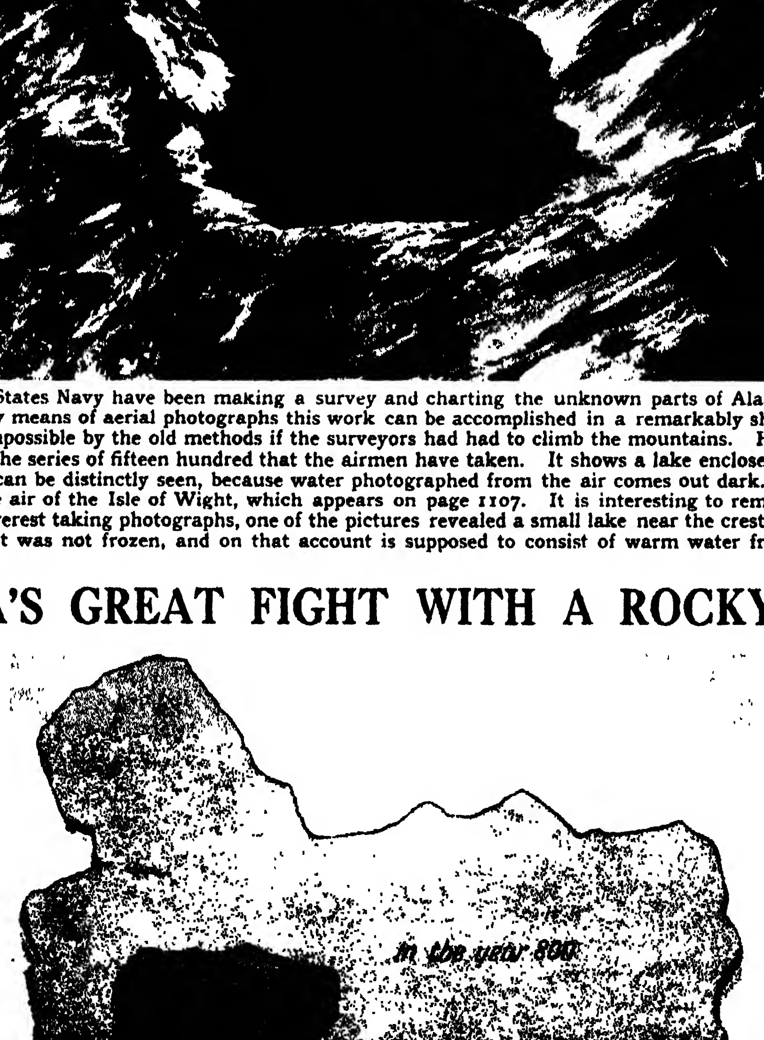
A LAKE AMONG THE ICE-CLAD PEAKS

The airmen of the United States Navy have been making a survey and charting the unknown parts of Alaska, one of the most difficult countries in the world. By means of aerial photographs this work can be accomplished in a remarkably short space of time, whereas it would have been almost impossible by the old methods if the surveyors had had to climb the mountains. Here is an interesting photograph which forms one of the series of fifteen hundred that the airmen have taken. It shows a lake enclosed by the jagged ridges of the ice-clad mountain, which can be distinctly seen, because water photographed from the air comes out dark. We have already seen this in the photograph from the air of the Isle of Wight, which appears on page 1107. It is interesting to remember that when the British airmen flew over Mount Everest taking photographs, one of the pictures revealed a small lake near the crest of the mountain. Like this one in Alaska, it was not frozen, and on that account is supposed to consist of warm water from a hot spring

THE SEA'S GREAT FIGHT WITH A ROCKY ISLAND

The relentless war which the sea wages against the land has never been better exemplified than in the case of the little rocky island of Heligoland. This island, which was once British and before that belonged to Denmark, lies in the North Sea off the coast of Germany. It has a circumference of three miles, and is 190 feet high, but it was not always so small.

In the year 1300 it was 45 miles round, and in 800 it was 120 miles in circumference. But all the time the waves have been wearing away and breaking up the rocky coast, till at last the island is little more than a speck of rock in the midst of the sea.



How Heligoland has been washed away by the sea during eleven centuries

It is made of limestone and sandstone rock, which is easily broken up by the waves and weather. On the south-east shore there is a flat bank of sand composed of the ground-up fragments that have been broken from the cliff.

Altogether the island is one-fifth of a square mile in area. After it was ceded to Germany by Great Britain in 1890, a great deal was done to protect the island from further destruction. Artificial cliffs were constructed, and the area of the island was slightly increased by dredging the Elbe and depositing on the island the material so obtained. The word Heligoland, which is German, means "Holy Island."

HOW BRITANNIA RULED THE WAVES

The fact that right through the nineteenth century Great Britain was unquestioned mistress of the sea, was due to Nelson's great victory at Trafalgar, the most decisive naval victory that the world has ever seen. "The Nelson touch" has become a legend, but it is still a potent phrase and although few people are aware of the fact, it was Nelson's own phrase. Here is the story of the great victory of Trafalgar, and its hero

It is doubtful if there has ever been any Englishman in whom his countrymen had so profound a confidence as Nelson. The "Nelson Touch" has become a legend. Whenever the country is in peril in time of war and victory tarries, there is a cry from all quarters for the Nelson Touch. The expression was Nelson's own, and it may be interpreted as an intuition of what should be done to inflict a crushing defeat on the enemy, and an instant determination to do it.

The Nelson Touch was seen at the Battle of the Nile, and later on at Copenhagen, but never was it better exemplified than in the great victory off Cape Trafalgar, which gave to England the mastery of the seas for a century.

There has certainly never been a victory like it in modern times. It destroyed for ever the dreams of Napoleon, and removed the threat of invasion which had caused disquiet in England for many years.

The Sea-Sick Admiral

Horatio Nelson scarcely seemed the man who would ever become a great and victorious admiral. Small and frail, he was all his life subject to sea-sickness. When as a lonely child of twelve he joined the Navy, he was emaciated by repeated attacks of ague, and he suffered from ill-health right through his life, even up to the great victory which has made his name immortal. But though ill-health harassed him throughout his life, it never hindered him.

When only fifteen he went on an expedition to the Arctic seas, had a fight with a Polar bear, and then after going to the East Indies was invalided home. From the first he was noted for his great bravery and his application to work, and in 1778 when he was twenty he received his first command.

He took a conspicuous part in the great victory over the French off Cape St. Vincent on February 14th, 1797, and was promoted to the rank of rear-admiral. He was in command of the squadron that blockaded Cadiz, and during a night attack on Santa Cruz lost his right arm. He had previously lost the sight of his right eye from the splinters of an exploded shell.

In 1798 he was placed in command of a small squadron to watch the movements of the French fleet in the Mediterranean, and on August 1st came upon the hostile fleet anchored in Aboukir Bay near Alexandria.

The French soon learnt the meaning of the Nelson Touch, for the English admiral at once attacked with such fury and skill that the whole French fleet except four ships was taken or destroyed. No wonder the victory was hailed with delight in England, and honours were showered upon Nelson, who was made a baron.

In 1801 he went as second in-command under Sir Hyde Parker with the British fleet to the Baltic. A confederacy had been formed between Russia, Sweden and Denmark, which, though not professing to be directly hostile to England, was determined to resist the search of neutral vessels by British ships in order to seize any French goods that might be found in them.

Nelson at prayer in his cabin on the eve of Trafalgar. From the painting by Barker

Parker sent Nelson to attack Copenhagen. Nelson determined to get close to the enemy so that the English shot should not miss its mark. The battle was a fierce one, and Admiral Parker, viewing the scene from a distance, feared that Nelson was in danger of defeat. He therefore hoisted a signal ordering the English fleet to cease fighting and retire.

When the signal was seen it was reported to Nelson, who pretended not to hear. But when the news was repeated, he said to a captain standing near, "You know, Foley, I have only one eye; I have a right to be blind sometimes," and lifting his telescope to the eye which had no sight, and levelling it at Admiral Parker's ship, he exclaimed: "I really do not see the signal!"

Some of the frigates, however, had seen it, and retreated; but Nelson continued the battle, and before long the Danish fire slackened, and then ceased. Nelson was made a viscount for his great victory at Copenhagen, and when Sir Hyde Parker was recalled he was given the sole command.

Watching for the Enemy

When in 1803 he received the command of the Mediterranean Fleet he took his station off Toulon, and from May in that year to August, 1805, he left his ship only three times. It was typical of the man. He was determined to watch for the enemy and bring him to battle, so as to gain a decisive victory and give England the mastery of the seas. If his men were to remain on board watching he would stay on board with them.

Spain and France were allied as the enemies of England, although the Spaniards were only half-hearted, and their combined fleets became a menace, for Napoleon hoped with their help to carry out his long-intended invasion of England.

Here was Nelson's chance. When the united French and Spanish fleets put to sea Nelson went in search of them. He beat about the Mediterranean, pursued them to the West Indies, and then, finding they had dodged him, returned in pursuit.

There were many conflicting accounts of their movements, but Nelson could

get no definite information. Whenever news of the enemy was brought which seemed as if it might be true, Nelson set off in pursuit. How thorough he was can be seen by the following incident

Nelson's ships were refitting in Gibraltar, and the officers and men had gone ashore, while the linen for washing had also been landed. Weather conditions indicating that a fair wind was blowing up, a gun was fired from the *Victory*, and the Blue Peter run aloft as a signal to the men ashore to return.

"Here is one of Nelson's mad pranks," said an officer. But the admiral proved right. The fair wind blew up, the men hurriedly returned, and the ships sailed away, without their linen, to look for the enemy.

As the combined French and Spanish fleets were still elusive Nelson received orders to proceed to Portsmouth, and then learnt that the enemy ships had been seen off Cape Finisterre, and that they had put into Vigo Bay to refit. Nelson at once offered his services to the Government, and these were eagerly accepted.

Nelson and Wellington Meet

It was during this last stay in England that Nelson and the Duke of Wellington met for the first and last time in their lives. Wellington, then Sir Arthur Wellesley, had just come back from India, and Nelson was in the waiting room of the Secretary of State when Wellesley entered. Nelson did not know Wellesley, but Wellesley knew him from the many portraits that were to be seen everywhere.

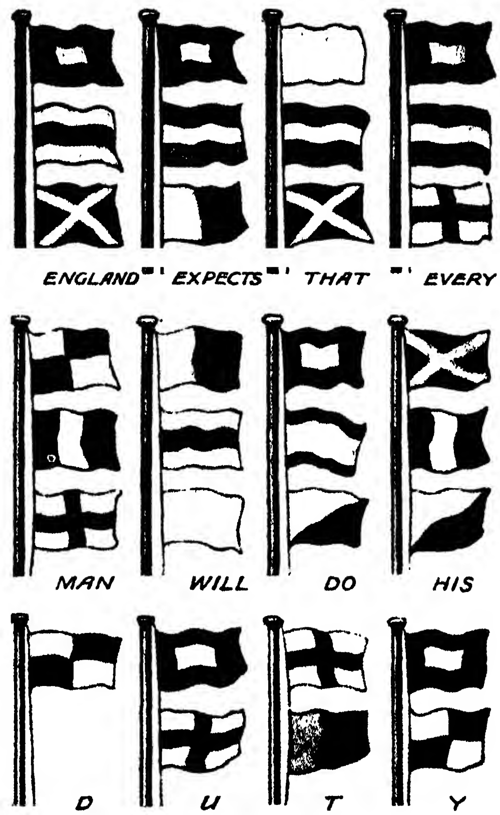
They talked for some time, and then Nelson went out of the room, apparently to find out who his companion was. Nelson seems to have explained some project for occupying Sardinia, in which he wanted Sir Arthur Wellesley to help by taking charge of the troops, but Wellesley had not shared Nelson's views.

Before sailing from Portsmouth with Admiral Collingwood as his second-in-command Nelson paid a visit to Lord Sidmouth, and sitting at a little study table the great admiral marked upon it with his finger diagrams explaining how he proposed to attack the combined fleets of France and Spain when he came up with them.

Later Lord Sidmouth had engraved upon this table the following inscription: "On the 10th day of September, 1805. Vice-Admiral Lord Viscount Nelson described to Lord Sidmouth, upon this table, the manner in which he intended to engage the combined fleets of France and Spain, which he expected shortly to meet. He stated that he should attack them in two lines, led by himself and Admiral Collingwood, and felt confident that he should capture either their van and centre, or their centre and rear. This he successfully effected, on the 21st of October, following, in the glorious Battle of Trafalgar."

When news was brought of the French and Spanish fleets Nelson exclaimed to the captain who brought it: "Depend on it, Blackwood, I shall yet give Mr. Villeneuve a drubbing."

After saying good-bye to his friends Nelson went down to Portsmouth and took breakfast in the George Inn before going on board the *Victory*. It is said that to escape the crowd he went



Nelson's famous signal to the fleet before Trafalgar

out through a back door. Crowds were waiting on the beach to see him embark, and they followed him to the very edge of the water. Many were in tears, others knelt down and blessed him as he passed.

"England," says Southey, "has had many heroes, but never one who so entirely possessed the love of his fellow-countrymen as Nelson. All men knew that his heart was as humane as it was fearless; that there was not in his nature the slightest alloy of selfishness or cupidity; but that with perfect and entire devotion he served his country with all his heart and with all his soul, and with all his strength; and therefore they loved him as truly and as fervidly as he loved England."

When at his embarkation the people cheered him, Nelson turned to Captain Hardy and said: "I had their huzzas before; I have their hearts now."

The *Victory* was accompanied by other ships and sailed to join the English fleet off Cadiz. By Nelson's strict instructions there were to be no salutes or rejoicings or flying of flags to welcome him, so that the enemy might be kept in ignorance of the arrival of the English reinforcements The men, however, received Nelson with the most unbounded enthusiasm, and that evening he wrote a dispatch to the Admiralty in which he said:

"When I came to explain to them the Nelson Touch it was like an electric shock. Some shed tears, all approved."

Nelson now had under his command 27 men of war. His great object was to get the French admiral Villeneuve and the Spanish admiral Gravina out of Cadiz. The combined enemy fleets consisted of 18 French warships and 15 Spanish, with half a dozen smaller vessels.

Presentiment of Death

Nelson was constantly sending orders to his ships about what he expected his men to do if once they could close with the French. At the same time he seems to have had a very strong idea that he would be killed when the battle took place, and he told Captain Hardy that he wished his body to be conveyed to England and to lie in St. Paul's Cathedral rather than in Westminster Abbey. The reason he gave for this is curious

When he was a boy he had often heard it said that Westminster Abbey was built on land which had once been a deep morass, and he thought in the course of ages that the land would again become a swamp, and that the Abbey would sink without leaving a trace.

On Saturday, October 19th, the enemy ships began to unmoor and come out of the harbour. Nelson with his main fleet was fifty miles away, but a chain of ships sent messages of every movement. The Admiral wrote several letters and then went on deck.

At three o'clock he heard that the enemy's fleet had put to sea with two British frigates following and watching them. By the afternoon of the following day, Sunday, the remainder of the French and Spanish fleets had come out of harbour, and the whole had united and formed in five columns There was no love lost between the French and Spaniards, and Nelson was afraid that they might not fight.

At last dawn came on Monday, October 21st, 1805, the day which was to see such a stupendous British victory. Nelson put on his admiral's frock-coat with the stars of the various orders he was entitled to wear embroidered on the left breast. He did not wear his sword, Trafalgar being, it is said, the

only action in which he ever appeared without one.

"I will not be contented," he told Hardy, "with capturing less than twenty sail-of-the-line."

About eleven o'clock in the morning he retired to his cabin, and when Lieutenant Pasco, who acted as signal-lieutenant on board the *Victory*, entered the cabin he found Nelson on his knees writing. He had just finished penning these words:

"May the great God, whom I worship, grant to my country, and for the benefit of Europe in general, a great and glorious victory; and may no misconduct in any one tarnish it; and humanity after victory be the predominant feature in the British fleet. For myself, individually, I commit my life to Him who made me, and may His blessing light upon my endeavours for serving my Country faithfully. To Him I resign myself, and the just cause which is entrusted to me to defend."

The British fleet was heading direct for the foe, the *Victory* leading. Nelson added a codicil to his will, which Captains Blackwood and Hardy witnessed. Then he went up on the poop and ordered Pasco to signal to the fleet: 'Nelson confides that every man will do his duty." The lieutenant (afterwards Admiral Pasco) suggested that "England" should be substituted for 'Nelson," and then he added: "If your lordship will permit me to substitute 'expects' for 'confides,' the signal will soon be completed, because the word 'expects' is in the vocabulary, and 'confides" must be spelt."

"That will do, Pasco," replied Nelson. "Make it directly."

And so the flags conveying the most famous signal the world has ever seen were hoisted, and the message was received with a great shout of enthusiasm throughout the fleet.

"Now," exclaimed Nelson, turning to Captain Blackwood, "I can do no more. We must trust to the great Disposer of all events and the justice of our cause. I thank God for this great opportunity to do my duty."

It was only to be expected that there would be skilled marksmen on board the French ships who, if they got the chance, would aim at the great British admiral, and the English officers were very concerned about this.

A number of them consulted together, and wanted to urge Nelson to take off his frock-coat, with the stars of his various orders, and to don something less conspicuous. But none cared to be the bearer of such a message, for on a previous occasion, when he had been advised to cover up the stars, he had said: "In honour I gained them, and in honour I will die with them"

The Battle Opens

The two fleets approached one another, Villeneuve, the French admiral, having formed his ships in a double line in close order.

Nelson, with his 27 men-of-war and four frigates opposed to the 33 men-of-war and seven frigates of his foe, prepared to attack in two lines. Nelson himself, in the *Victory* led the one line of 14 vessels, and Admiral Collingwood the other, consisting of 13 vessels.

The *Victory* (marked with a X), breaking through the French line at Trafalgar. From the painting by Huggins

As the *Victory* neared the French fleet, she was met by a galling fire, and had fifty men killed or wounded before one of her own guns was fired. Then, at a signal from the French admiral, the whole artillery of the enemy's van, formed of seven or eight ships, opened fire upon the *Victory*. "Never, perhaps, before in all maritime warfare," says a naval historian, "had so tremendous a fire been directed at a single ship."

Damage Under Fire

John Scott, Nelson's secretary, was killed instantly while talking to Captain Hardy. The *Victory* was within about 500 yards of the *Bucentaure* when her mizzen topmast went over the side, shot away for about a third of its length. Then the wheel was knocked to pieces, and a second or two later a double-headed shot killed eight marines who were on the poop.

Nelson at once asked the captain of marines to distribute his men about the ship, so that they might not suffer by being too closely grouped together. But though he was concerned for the safety of others, he had no regard for his own safety. For instance, the hammocks on his ship served as barriers against the enemy's grape and musket shot, but Nelson refused to allow these to be placed an inch higher than was usual to protect his head, as in that case they would hinder his view of the scene of battle.

Just as the fire began, Nelson was pacing the deck with Hardy, when a splinter struck the captain's foot and tore the buckle from his shoe. Both men stopped suddenly and examined one another, each fearing that the other had been hurt.

"This is too warm work, Hardy, to last long," said Nelson, with a smile; and then he added that, in all his long experience of battle, he had never seen such coolness and courage as the men of the *Victory* were showing.

Just after noon the *Victory* opened fire on the *Bucentaure*. She discharged a 68-pounder carronade loaded with a round shot and a keg filled with five hundred musket balls. These were shot right into the French ship's cabin window, and then as the *Victory* forged ahead, all the remaining guns of her broadside were fired, one after the other, some with double and some with treble shots

The thick clouds of black smoke from the gunpowder of so many guns nearly suffocated the men in the *Victory*, and all those on the quarter-deck of the ship, including Nelson, were begrimed with dust.

This first discharge of the *Victory's* guns was disastrous to the *Bucentaure*. Twenty of the French vessel's guns were dismounted, and the loss in killed and wounded was nearly 400.

Captain Hardy pointed out to Nelson that it was impossible to pass through the enemy's line without running aboard one of the ships which were coming together ahead of her.

"Go on board which you please; take your choice," replied Nelson.

And so Hardy decided to run aboard the *Redoubtable*, which was to starboard. That ship fired one broadside

Nelson falling wounded on the deck of the *Victory* at Trafalgar. From the painting by Benjamin West

and then, through fear of being boarded by the English, let down her lower-deck ports and contented herself for the rest of the battle with keeping up a fire of musketry from her tops.

It is said that the Frenchmen were so afraid that the *Victory's* guns would set fire to their ship—the muzzles of her guns, when the pieces were run out, touching her sides—that the fireman of each gun of the *Redoutable* stood with a bucket of water ready to throw it when the *Victory* fired.

Southey tells us that, setting an example himself of humanity, Nelson twice gave orders to cease firing upon the *Redoutable*, supposing that she had struck because her great guns were silent. It appears she carried no flag, and so there was no means of instantly knowing whether she had struck or not. It is sad to think that it was from this ship, which he had thus twice spared, that the great English admiral received his death.

Hardy and Nelson were pacing the deck of the *Victory*, and as Hardy turned to retrace his steps he saw Nelson in the act of falling. Before he could support him the admiral had dropped with his face on the deck. Strange to say, it was exactly the same spot where his secretary Scott had been killed a short time before, and the blood of this poor fellow, still fresh, stained Nelson's clothes.

"They have done for me at last, Hardy," said Nelson.

"I hope not," cried Hardy.

"Yes," was the reply, "my back bone is shot through."

Then he noticed that the tiller ropes which had been shot away had not been replaced, and he gave orders that new ones should be rove immediately.

The wounded admiral was lifted and carried below to the cockpit, and always thinking of others, he himself spread his handkerchief over his face and stars so that his men might not know who it was that was being carried down. If only he had concealed the badges of honour earlier he would probably not have been shot.

The Scene in the Cockpit

The cockpit was crowded with wounded and dying men. It was gloomy with the light of a few smoking oil lamps, and the atmosphere was almost insufferable. The groans of the wounded mingled with the thunder of the artillery overhead.

Nelson was carried with difficulty over the bodies of the wounded and laid in a midshipman's berth. The surgeon, Dr. Beatty, then went to him and began to examine him. "Ah, Mr. Beatty," said Nelson, "you can do nothing for me. I have but a short time to live; my back is shot through."

Realising that nothing could save his life, he insisted that the surgeon should leave him and attend to those to whom he might be more useful. When the surgeon returned Nelson said: "Alas, Beatty, how prophetic you were!" referring to the fear that had been expressed that his decorations would expose him to the fire of the French sharpshooters.

His clothes were removed and he was covered with a sheet, but although he was in great pain, especially when the surgeon probed the wound to find the ball, yet he thought of various friends and particularly asked to be remembered to them.

"I am confident that my back is shot through," he said, but the secret of the admiral's mortal wound was maintained by the few who knew, until the victory of the English over the combined fleets was assured.

Little could be done for the great admiral. He was suffering terribly from thirst and repeatedly called for drink and asked to be fanned with paper, saying feebly, "Fan, fan, drink, drink." He was given lemonade and wine and water, but even amid his sufferings he was still concerned for the result of the battle and the safety of his friend Captain Hardy. When told that the enemy had been decisively defeated, he said: "It is all over," and asked to see Hardy.

When the captain was unable to come for some time Nelson exclaimed: "He must be killed; he is surely destroyed." Then a message was brought that it was impossible for Hardy to leave the deck for the time being, but he would descend the moment a chance offered.

The guns of the *Victory* were still

firing, and the concussion added to Nelson's pain, whereupon he exclaimed: "Oh, *Victory*, *Victory*, how you distract my poor brain!" adding after a pause, "How dear is life to all men!"

He had been lying in the cockpit over an hour before Hardy could visit him. They shook hands in silence, and Nelson then said: "Well, Hardy, how goes the day with us?"

"Very well," replied Hardy, "ten ships have struck, but five of the van have tacked and show an intention to bear down upon the *Victory*. I have called two or three of our fresh ships round, and have no doubt of giving them a drubbing."

"I hope," said Nelson, "none of our ships have struck?"

"No, my lord," replied Hardy, "there was no fear of that."

There was a pause, and then Nelson said, "I am a dead man, Hardy. I am going fast. It will be all over with me soon. Come nearer to me." And then he gave the captain various messages and commissions to his friends.

Beatty the surgeon was again summoned to his side, and learning from Nelson his symptoms exclaimed: "My lord, unhappily for our country, nothing can be done for you." Then he had to turn away to conceal his grief.

"God be praised," said Nelson feebly, "I have done my duty."

Hardy had to leave him, but he returned fifty minutes later, and a second time they pressed hands. Then he congratulated Nelson on having gained a complete victory. He could not say exactly how many of the enemy's ships had been taken, but there were fourteen or fifteen at least.

"That is well," cried Nelson, "but I bargained for twenty." He asked Hardy not to throw his body overboard when he was dead, as he wished to be taken home to England for burial.

Then he said, "Kiss me, Hardy," and the captain knelt and pressed his lips to the dying admiral's cheek. "Now I am satisfied," said Nelson. Hardy stood for some time in silence, and then kneeling again kissed his chief's forehead.

"God bless you, Hardy," said the admiral, and the captain then hurried away on deck.

Soon afterwards Nelson became speechless, and at last, again muttering feebly "Thank God I have done my duty," he expired at half-past four.

Southey tells us how it was that he had been shot. "Within a quarter of an hour after Nelson had been wounded," he says, "about fifty of the *Victory's* men fell by the enemy's musketry. They, however, on their part were not idle, and it was not long before there were only two Frenchmen left alive in the mizzen-top of the *Redoutable*. One of them was the man who had given the fatal wound; he did not live to boast of what he had done.

The Sharpshooter Shot

"An old quartermaster had seen him fire, and easily recognised him because he wore a glazed cocked hat and a white frock. This quartermaster and two midshipmen, Mr. Collingwood and Mr. Pollard, were the only persons left on the *Victory's* poop; the two midshipmen kept firing at the top, and he supplied them with cartridges. One of the Frenchmen, attempting to make his escape down the rigging, was shot by Mr. Pollard, and fell on the poop.

"But the old quartermaster, as he called out 'That's he, that's he!' and pointed to the other, who was coming forward to fire again, received a shot in his mouth and fell dead. Both the midshipmen then fired at the same time, and the fellow dropped in the top."

When the Battle of Trafalgar was over 17 French and Spanish ships had been captured and one burnt. Seven ships which escaped from the battle were all captured later, and though the English lost 1,587 men, the loss of the French and Spaniards was much greater.

After the battle: the *Victory* with the body of Nelson on board being towed into Gibraltar

The French admiral, Villeneuve, was captured and taken to England, where he remained till the following year. On his way back to Paris he stopped at Rennes and was found mysteriously dead in bed. It was given out that he had committed suicide, but no one can say for certain how he met his death.

Nelson's body was brought home for burial, and very strange was its journey. There was no lead available for the construction of a coffin, and so his body was placed in a large cask, which was filled with brandy and sealed. The cask was stood on end and a sentinel kept guard by its side.

The *Victory* spent five weeks in making the journey to Spithead, where Nelson's body was taken from the cask and examined. The ball that had passed through his spine was found lodged in the muscles of his back.

The body was wrapped in cotton garments, placed in a leaden coffin with brandy, camphor and myrrh, and then after this coffin had been placed in a wooden one the body was taken on by the *Victory* in the cabin that Nelson had occupied in his lifetime.

It proceeded to the Downs, and was then transferred to a yacht from Sheerness, where it was placed in the coffin that had already been prepared in Nelson's lifetime. It was here that the great sailor's remains were viewed by mortal eyes for the last time. As the coffin was lowered on to the yacht the *Victory* struck Nelson's flag at the fore and then it was hoisted half-mast high on board the yacht.

At Gravesend the military and naval honours which were to accompany the remains to their last resting place began. Everywhere that the yacht passed troops were drawn up, ships dipped their flags in salute and church bells were tolled.

At Greenwich the body was landed, and lay in state in the Painted Hall of Greenwich Hospital.

The burial took place as Nelson had wished, in St Paul's Cathedral, and the funeral was one of great magnificence. When Nelson's flag was about to be lowered into the grave the sailors who assisted at the ceremony rushed forward and tore it to pieces, that each might preserve a fragment.

Honours were heaped upon Nelson's relatives in memory of the Admiral's great victory and public statues were erected in many parts of the country, the most famous of course, being the column in Trafalgar Square.

But the joy and relief of the nation at the great victory were tempered if not completely spoilt by the tragedy of the victor's death, and there were many who declared that they would willingly have preferred that Nelson should have lived even at the expense of victory.

Trafalgar was one of the most decisive battles in the world's history. It paved the way to Waterloo and St. Helena. Englishmen can never forget the debt of gratitude they owe to Nelson for saving their country from invasion by the all-conquering Napoleon, and for making her the Mistress of the Seas.

THE SIMPLE PRINCIPLE OF THE PERISCOPE

The periscope is an important part of a submarine's equipment, for it enables the commander, while submerged, to see what is going on all round on the surface of the sea. But although the modern periscope is an intricate instrument, in a simple form it has been known and used for nearly a century. This picture shows the principle of the periscope, and any clever boy or girl can make one. It consists of two mirrors mounted in a frame and set at an angle of 45 degrees, one below the other. When held up, as shown, a scene on the other side of a wall is caught by the upper mirror and reflected down to the lower one where it can be seen. Naval periscopes are very complicated, a prism reflecting the scene down through a series of lenses to a second prism which directs it to an eyepiece

THE PERISCOPE AS THE SUBMARINE'S EYE

If it were not for the periscope the submarine commander would be practically blind when his vessel was submerged, but by means of this ingenious device he can see what is going on above the surface of the sea. The word periscope means to view around. The principle of the instrument is described here. A drawing showing a submarine and its periscopes is given in pages 1206-1207.

We have all heard of the periscope, that useful instrument on a submarine which enables the commander of the vessel when it is submerged to see what is going on all round at the surface of the sea.

The idea of being able to see without being seen is by no means new. So far back as 1687 Johann Hevelius, the famous German astronomer, invented an apparatus of this kind which he called the polemoscope, from two Greek words meaning war and to view. He gave it this name because he thought the instrument would be of great use in war, enabling men to see the enemy from behind a wall or trench without exposing the spectator to enemy fire.

It was used to a considerable extent for this purpose right down to the First World War, but it is as an eye for the submarine that the periscope has most proved its value. It was at the end of the nineteenth century that the name of periscope was given to the apparatus. This name is made up of two Greek words, *peri*, around, and *skopein*, to watch, and it is an excellent name, for the periscope does really make it possible for the officer to watch over the surface of the sea around him.

The principle of the periscope is shown in the picture on the opposite page. It depends upon reflection, and the fact that light is reflected from a plane mirror at the angle at which it strikes the surface.

Two mirrors are arranged in some kind of frame at an angle of 45 degrees, one at the top and one parallel with it at the bottom. The apparatus is held up so that the upper mirror is above the top of a wall or trench and facing the object it is desired to see. Horizontal light-rays strike the face of the mirror and are reflected vertically down upon the other slanting mirror. Here the rays are again reflected so that they are once more horizontal, and in this way what is happening on the other side of the wall or trench can be seen clearly. Periscopes of this kind were used in the trenches in France and Flanders during the 1914-18 War.

Of course, for the submarine the idea has been greatly developed and improved. There it is based on the principle of the dark room in photography, and by means of a telescopic arrangement the tube can be raised above the surface of the water or lowered as desired.

The tube of a submarine telescope is usually about thirty feet long and six inches in diameter. At the top the diameter is sometimes reduced to two inches or less. In order that the field of view may be increased, the periscope is fitted throughout its length with a whole series of lenses which have the same effect as if the spectator's eye were near the top of the tube.

It may be asked why the tube should be so narrow at the top. Well, this is to make it less conspicuous and reduce the chances of its being seen by an enemy. On the other hand, it must be at least six inches at the place where it is in the water, for as the submarine moves along the force of the water tends to bend the tube. A smaller tube would bend so much as to shut off the vision.

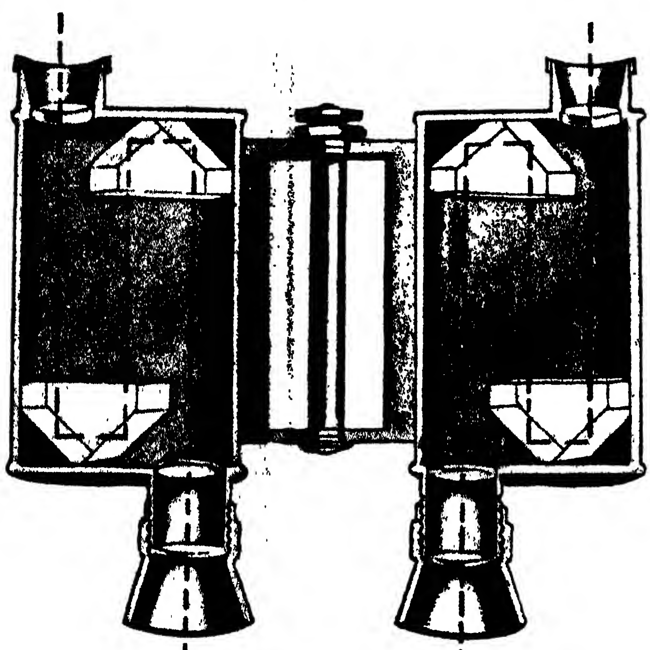
A curious use to which the periscope has been adapted in America is that of showing on a screen in one room a surgical operation being performed in an adjoining operating theatre. A mirror and prism are arranged immediately over the operating table and the scene is caught and directed through a periscope tube placed horizontally.

By means of a powerful light the reflection is thrown upon a screen, a lens magnifying the scene. In this way a far larger number of students can watch the details of the operation than would be possible without the assistance of the instrument.

In some hospitals, operations are now televised and the picture projected on to a cathode screen for the benefit of students in another room.

In the latter half of the nineteenth century opera-glasses were sometimes made on the periscope principle so as to enable people to look obliquely at others without appearing to be staring at them.

Prismatic binoculars are made on somewhat the same principle, as can be seen from the picture on this page. The great advantage of this form of field glass is that the instrument is very greatly shortened and reduced in weight, and at the same time the range is increased. The optical value of such a pair of binoculars is very much the same as that of a telescope or pair of glasses with lenses of similar magnifying power, but with tubes more than twice the length.



Here we see how prismatic binoculars work, and why they can be made so much shorter than ordinary binoculars of equal power. We see the binoculars in the position in which we hold them when looking through them. Inside each tube is arranged a pair of prisms. The rays of light, indicated by dotted lines, from the distant scene enter through the lenses, pass to the prisms opposite and are bent and reflected by these to the second pair of prisms, where the rays are again bent and reflected through the lenses of the eyepieces to our eyes.

EXPERIMENTS WITH A BOUNCING BALL

There are many interesting scientific facts which we can learn from apparatus no more elaborate or expensive than an ordinary indiarubber ball

Let us take the ball and bounce it up and down vertically on the ground, seeing how many times we can make it bounce without letting it go off at an angle. Perhaps we can do this a dozen or a score of times, as we have done it on many occasions before.

But have we ever stopped to wonder why sooner or later the ball goes off at an angle and so we spoil our score? Well, the reason is that a ball thrown against a flat surface always bounces off at the same angle as that at which it struck the surface.

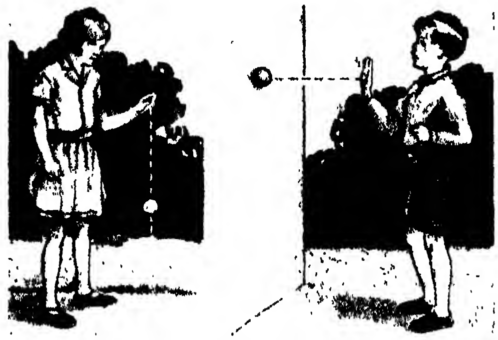
Now if we throw the ball down vertically the angle at which it strikes the ground is one of 90 degrees, that is, a right angle, and so the ball returns or bounces back to our hand at the same angle, which means it comes up vertically. If, however, by chance we strike the ball with our hand not quite evenly so as to make it strike the ground at some other angle, instead of coming up vertically it goes off at a slant and thus we miss it.

We can prove that the ball bounces off the ground in the opposite direction at the same angle at which it struck, by a very simple experiment. Let us stand a little distance from a companion and throw the ball at a spot on the ground midway between us both, trying to let the path of the ball from our hand to the ground make an angle with the ground of 45 degrees. We shall find that the ball will bounce up in the other direction, towards our companion, at the same angle

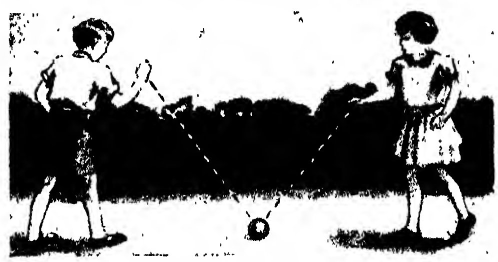
It is quite interesting to move farther and farther away, so that the angle at which the ball hits the ground becomes more and more acute. It always bounces up in the other direction at the same angle The second picture makes the matter clear.

Of course, instead of throwing the ball at the ground we can pitch it against a vertical wall, when the same facts are true. If the ball is thrown directly at the wall so as to make a right angle, it comes back to the hand, but if it is thrown so as to strike the wall at some other angle, it goes off at the same angle in the other direction.

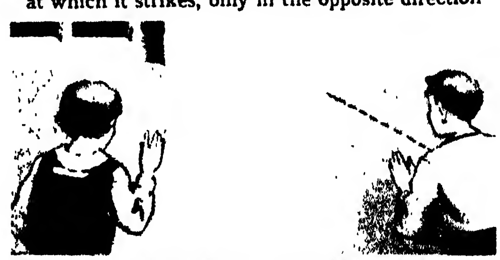
These simple experiments with a rubber ball are interesting because light behaves in the same way when it strikes a mirror. Let two of us stand at some distance from one another looking into a mirror, which is midway between us. We each see the other, although we cannot see ourselves, because the light rays from each person strike the mirror at an angle and are reflected, or bounce off, we may say, at the same angle in the opposite direction The game of billiards depends upon the fact that an elastic ball rebounds from a surface that it strikes at the same angle at which it struck the surface. A good billiard player is one who utilises his knowledge of this fact.



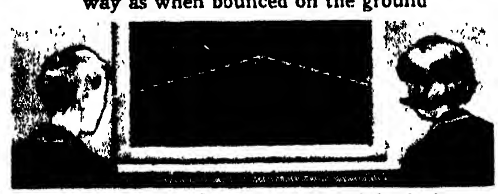
A ball bounced at right angles to the ground or a wall returns at the same angle



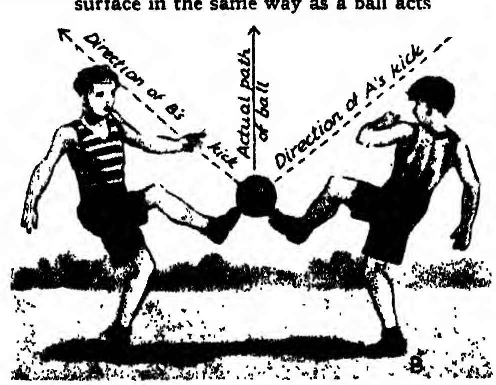
A ball rebounds from the ground at the same angle at which it strikes, only in the opposite direction



A ball thrown at a wall at an angle acts in the same way as when bounced on the ground



Rays of light are reflected or bounced back from a surface in the same way as a ball acts



A ball kicked in two directions at once goes in neither but along a line somewhere between

One other experiment with a ball is worth carrying out, this time with a football. We bounce it on the ground and then two of us kick it at the same angle but in different directions What happens to the ball? Well, it goes in neither direction in which it is kicked, but somewhere between the two.

"Of course it does!" says someone. Yes, but why? Well, science tells us that if two forces strike an object such as a ball, tending to drive it in opposite directions, the forces and directions can be represented by two straight lines, their lengths being in proportion to their forces

Now, if we use these two lines as two sides of a parallelogram, and draw the other two sides, the actual direction in which the ball will go is represented by the diagonal of the parallelogram.

If the lines of direction of the two kicks are drawn so that their lengths represent the amount of force in each case, then the diagonal of the parallelogram formed upon them will represent not only the direction but the distance to which the combined kicks will carry the ball.

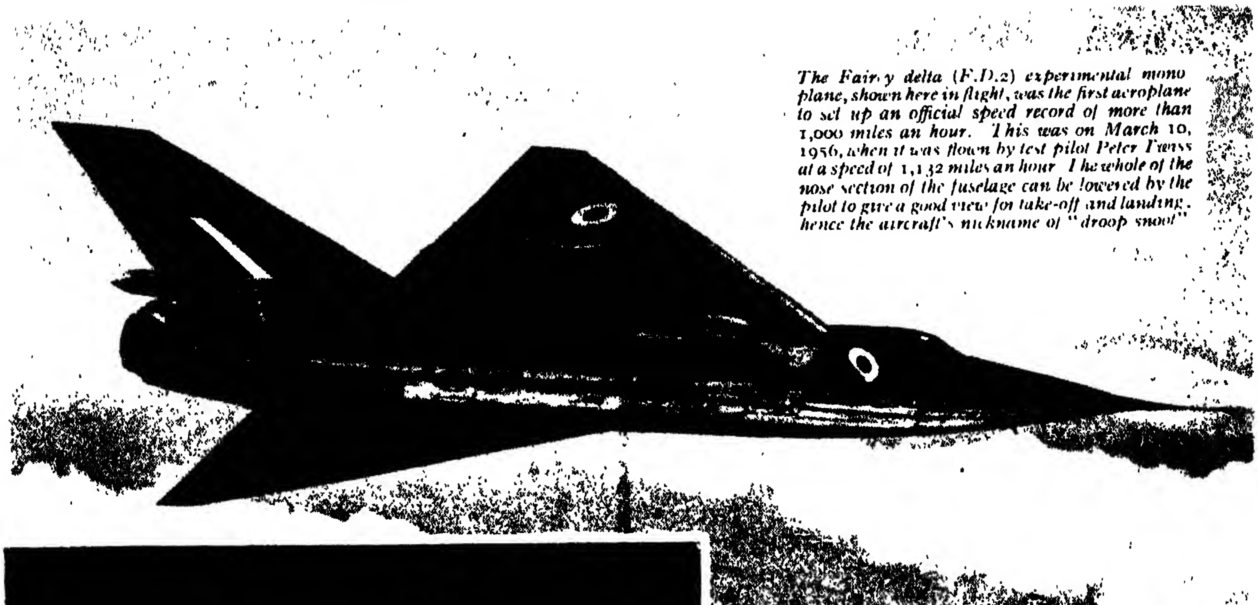
We have already seen on Page 937 how the parallelogram of forces comes into play when a ball is hurled into the air.

The extent to which a ball bounces depends upon its elasticity We have seen and tested this in the experiments described on Page 595. In those experiments a rebound depended upon the elasticity of the material of which the various balls used were made.

We can carry out further experiments with a ball by bouncing it upon surfaces of different materials If we take our ball out into the street or playground and bounce it on the hard stone or concrete surface we shall find that it will bounce up very high and continue bouncing for some time, reaching a less height at each bounce, as the energy originally given to it is used up.

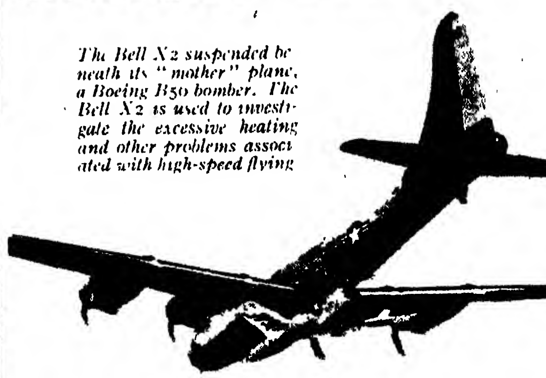
But if we now take the same ball on to a beach of soft sand and bounce it there we shall find that the ball hardly rises at all. When we threw it down on the beach, we imparted to the ball as much energy as we did when we threw it on the pavement or playground. But in the case of the sand the energy of the ball is used up in moving the loose grains, and when the energy is used in this way it is not available for throwing the ball up again. The hard stone pavement or concrete playground is much more elastic than the loose, soft sand.

THE FIRST AEROPLANES TO FLY AT 1,000 M.P.H.

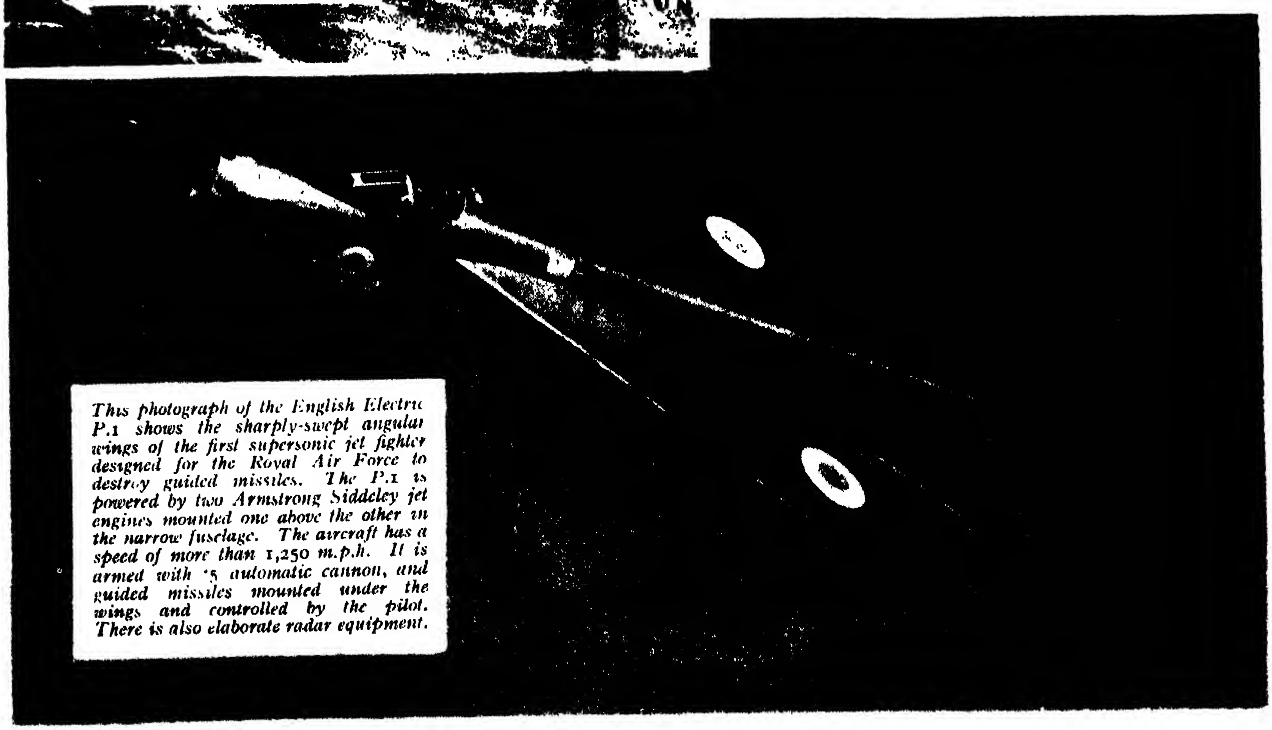


The Fairey delta (F.D.2) experimental monoplane, shown here in flight, was the first aeroplane to set up an official speed record of more than 1,000 miles an hour. This was on March 10, 1956, when it was flown by test pilot Peter Twiss at a speed of 1,132 miles an hour. The whole of the nose section of the fuselage can be lowered by the pilot to give a good view for take-off and landing, hence the aircraft's nickname of "droop snoot".

The Bell X2 swept-wing rocket-powered research monoplane, here seen above hill country in Texas, has flown at a speed of 1,900 miles an hour. The speed is not officially recognised, as the aircraft was carried to an altitude of 30,000 feet by a "mother" plane, and the flight lasted for only a few seconds.



The Bell X2 suspended beneath its "mother" plane, a Boeing B50 bomber. The Bell X2 is used to investigate the excessive heating and other problems associated with high-speed flying.



This photograph of the English Electric P.1 shows the sharply-swept angular wings of the first supersonic jet fighter designed for the Royal Air Force to destroy guided missiles. The P.1 is powered by two Armstrong Siddeley jet engines mounted one above the other in the narrow fuselage. The aircraft has a speed of more than 1,250 m.p.h. It is armed with ·5 automatic cannon, and guided missiles mounted under the wings and controlled by the pilot. There is also elaborate radar equipment.

DONKEY-POWER FOR RAISING WATER

We often hear of horse-power, a reminder that when steam-engines came into use their power was compared with the work that a horse could do. Here we see an example of donkey-power, the great wheel on a farm at Kenworth, near Dunstable, used for drawing water from a well, being worked for centuries by means of a donkey. The animal, or rather a succession of animals, has been trained to go into the wheel and walk, turning the great apparatus as it did so. The animal that turned the wheel has for centuries been fitted with curious up-turned shoes to facilitate their movement in the wheel. The great wheel at Carisbrooke Castle, in the Isle of Wight, used for drawing water from the deep well there is worked by a donkey in the same way. Of course, in the days before the invention of the steam engine, a machine of this kind worked by an animal was a very useful device. Nowadays it is merely a curiosity

MACHINES WORKED BY ANIMAL POWER

The giant turbine of to-day, whether driven by steam or water-power, is only the successor or descendant of much simpler machines that did good service in the days of old, and a few examples of which are still to be seen. On this page we read something about the treadmill worked by man or beast, which provided power for the drawing of water or other useful purposes

PEOPLE often speak of the treadmill, who have a very vague idea indeed of what a treadmill is or was. The name was given to a device introduced by Sir William Cubitt in 1818 for use in prisons and it consisted of a large cylinder of wood with many rows of steps upon it.

It was arranged in an iron frame and prisoners used to step on to the cylinder and then, steadying themselves by holding a bar, walk up the steps continuously. As they did so their weight caused the great cylinder to rotate, so a constant movement was kept up.

Sir William Cubitt's idea was that the man-power of the prisoners should be turned to useful purposes. In some cases the treadmills were linked up with machinery which was worked by their means, but in many cases the men simply trod the mill as a punishment and nothing resulted from their labours. Even at the beginning of the present century there were a few treadmills in English prisons, but they have now been discontinued.

It was really the last attempt in England to use man-power on a large scale for the production of rotary motion. It is certainly a very unproductive form of power, even when produced by prisoners. Steam and electricity or falling water do it so much better.

Of course, Cubitt's device was not a new invention. The treadmill worked by man or animal power had long been in use and even to-day in a few places, the idea is still carried out for the drawing of water, as at Carisbrooke Castle in the Isle of Wight. There the mill takes the form of a tread-wheel, fifteen feet in diameter, which is worked by a donkey. As it walks on the inner part of the rim the wheel rotates and draws up water from a well 145 feet deep.

There are one or two other similar wheels in different parts of the country, where either a donkey or a man by walking constantly inside the rim turns the wheel and works a windlass. In Wales somewhat similar devices are worked by dogs for turning churns. Slats of wood nailed across the wheel give a foothold for the man or animal. The old spits in mansions were often worked by dog-power.

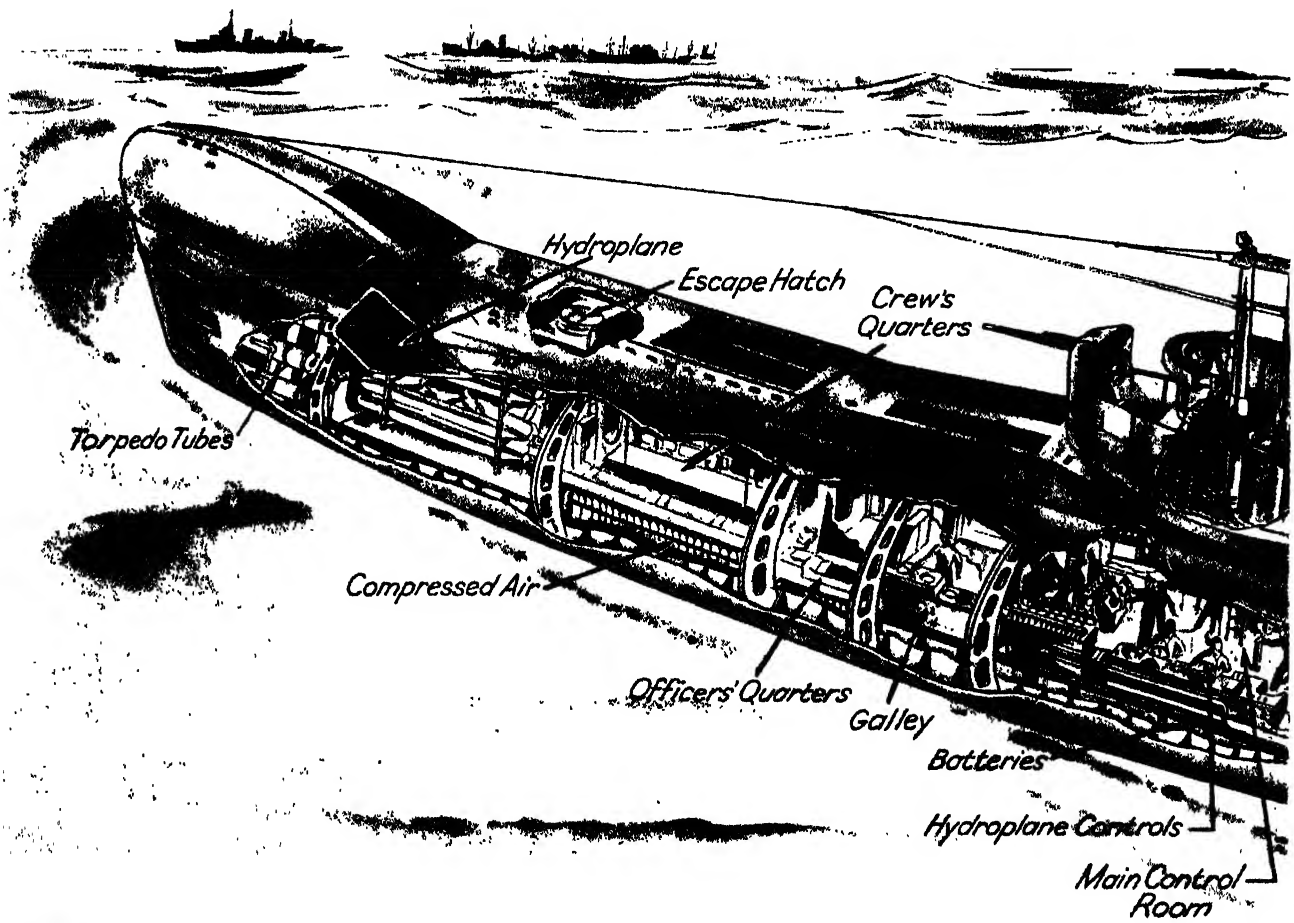
Such old devices are interesting as being examples of early machinery and the determination of man to use some power beyond his own to do his work. Of course, all such crude devices must eventually give way, if they have not already done so, to machinery worked by steam, electricity, or petrol engines.

To realise how far man has advanced in his improvement of machinery, we have only to compare these old treadwheels with the fine steam turbine shown on pages 1222 and 1223.

A treadmill worked by man-power at Bearworth in Hampshire for the purposes of drawing water from a 300 ft. well. The wheel is twelve feet in diameter and as the man walks the great wheel moves round and round turning a windlass

HOW AN UNDERWATER WARSHIP

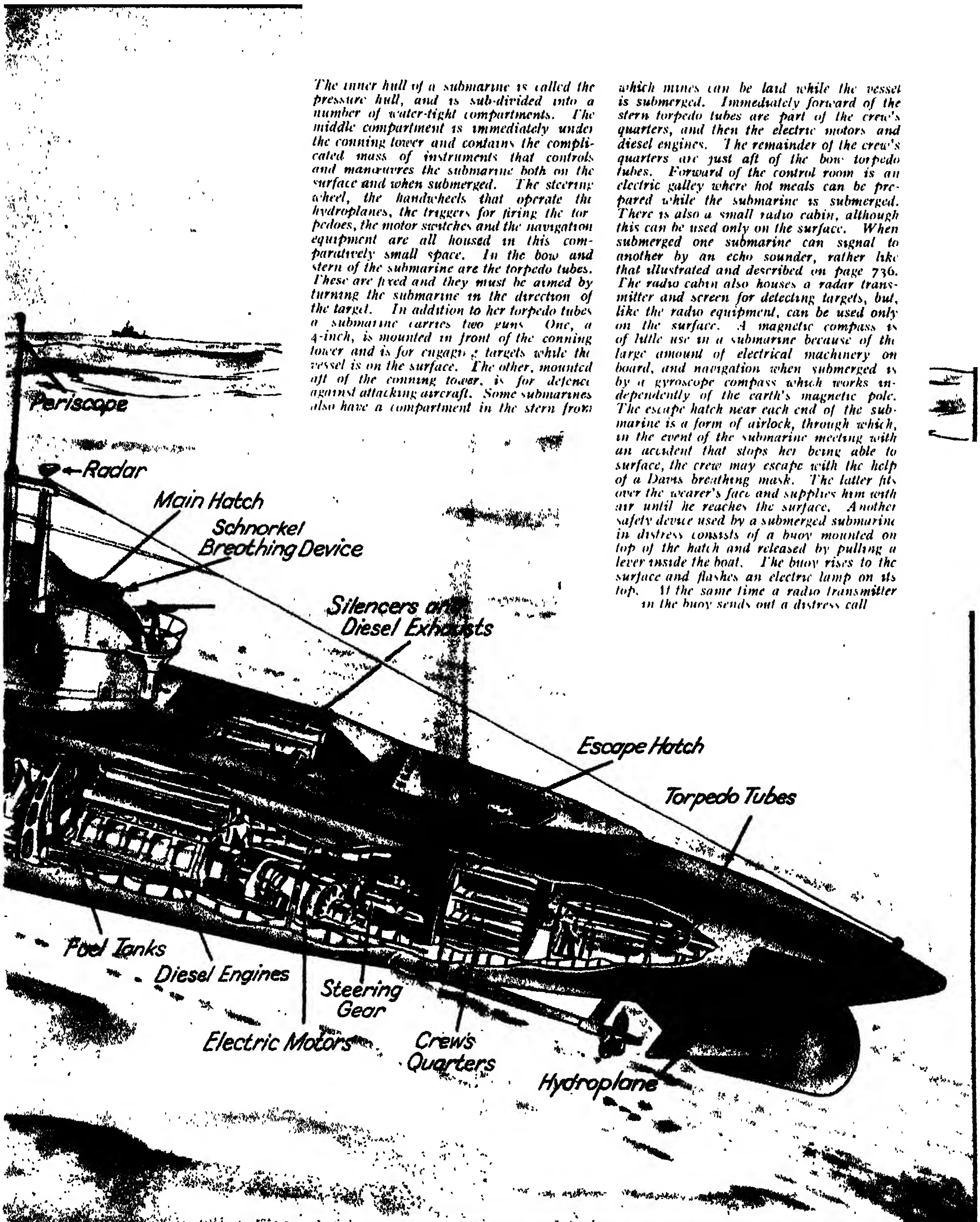
A submarine is really a ship within a ship; that is, it has an outer and an inner hull. When the commander of a submarine wishes to submerge he orders the ballast tanks in the outer shell or hull to be flooded with sea water. This is done by turning a wheel in the control room which opens a series of valves. At the same time the hydroplanes at the stern and bow are turned down, so forcing down the bow of the vessel. The hydroplanes are a form of rudder, but instead of moving from side to side they move up and down. As the submarine dives, the diesel engines used for surface cruising are shut off, and the propellers are driven by electric motors taking their power from storage batteries. When the required depth is reached, manipulation of the hydroplanes keeps the boat level. A submarine can dive to depths of between 200 and 400 feet without the rush of water pressure damaging the hull. When the captain wants to see what is happening on the surface of the water above him, the submarine is kept at what is called periscope depth; that is, with the top of the periscope about three feet above the surface of the sea. When the submarine is to be brought to the surface again, compressed air is blown into the flooded submerging tanks forcing the water out. The hydroplanes are turned upwards and help the boat to the surface. The electric motors are switched off and the propeller shaft clutched into the diesel engine.



Until the 1939–45 War, the length of time a submarine could remain submerged was strictly limited and depended upon two things: the state of the batteries driving the electric motors, and the supply of air for the crew. Cruising at a speed of ten knots, the submarine could move about for a couple of hours; she then had to come to the surface to charge her batteries, which is done from a generator driven by the diesel engine. The diesel engine cannot be run when the submarine is submerged as it not only uses up air, but its exhaust creates a poisonous atmosphere. If necessary the submarine could remain motionless on the seabed for 48 hours, by which time the air inside the hull was breathable only by releasing oxygen or by burning chemical candles which absorb the poisonous carbon monoxide. In 1944, the Germans fitted to their submarines an underwater breathing device called a Schnorkel. This consisted of two retractable tubes which could be extended above the surface of the sea. The lower end of one tube was attached to the air intake of the engine, and drew in air from the surface through an extractor fan. The end of the other tube was fixed to the engine exhaust and carried the poisonous fumes to the surface. In this manner the diesel engines could be run underwater without harm to the crew. After the 1939–45 War a Schnorkel device was fitted to British submarines.

Here you can see what it is like inside a large ocean-going submarine and have some idea of the mass of equipment and machinery that has to be crammed into a small space. A submarine of the type illustrated displaces about 1,120 tons on the surface and 1,700 tons when submerged. Her length is 320 feet and her surface speed is about 18 knots. She can travel a distance of 8,000 miles on the surface without refuelling, but submarines seldom make such long voyages and generally operate at ranges up to 1,000 miles from land bases or from supply vessels called mother ships. During the 1939–45 War the Japanese navy built huge submarines displacing 5,000 tons and having a surface speed of 21 knots but they were not successful.

GOES ABOUT HER DANGEROUS DUTIES



The inner hull of a submarine is called the pressure hull, and is sub-divided into a number of water-tight compartments. The middle compartment is immediately under the conning tower and contains the complicated mass of instruments that controls and manœuvres the submarine both on the surface and when submerged. The steering wheel, the handwheels that operate the hydroplanes, the triggers for firing the torpedoes, the motor switches and the navigation equipment are all housed in this comparatively small space. In the bow and stern of the submarine are the torpedo tubes. These are fixed and they must be aimed by turning the submarine in the direction of the target. In addition to her torpedo tubes a submarine carries two guns. One, a 4-inch, is mounted in front of the conning tower and is for engaging targets while the vessel is on the surface. The other, mounted aft of the conning tower, is for defence against attacking aircraft. Some submarines also have a compartment in the stern from which mines can be laid while the vessel is submerged. Immediately forward of the stern torpedo tubes are part of the crew's quarters, and then the electric motors and diesel engines. The remainder of the crew's quarters are just aft of the bow torpedo tubes. Forward of the control room is an electric galley where hot meals can be prepared while the submarine is submerged. There is also a small radio cabin, although this can be used only on the surface. When submerged one submarine can signal to another by an echo sounder, rather like that illustrated and described on page 736. The radio cabin also houses a radar transmitter and screen for detecting targets, but, like the radio equipment, can be used only on the surface. A magnetic compass is of little use in a submarine because of the large amount of electrical machinery on board, and navigation when submerged is by a gyroscope compass which works independently of the earth's magnetic pole. The escape hatch near each end of the submarine is a form of airlock, through which, in the event of the submarine meeting with an accident that stops her being able to surface, the crew may escape with the help of a Davis breathing mask. The latter fits over the wearer's face and supplies him with air until he reaches the surface. Another safety device used by a submerged submarine in distress consists of a buoy mounted on top of the hatch and released by pulling a lever inside the boat. The buoy rises to the surface and flashes an electric lamp on its top. At the same time a radio transmitter in the buoy sends out a distress call

and were never used in action. Inventors had been trying to build submarines since the 17th century, but none was successful until 1885-91 when T. Nordenfeldt, a Swede, built three submarines for the German Navy. Thereafter considerable progress was made, particularly in the United States of America. The first submarine for the Royal Navy was built at Barrow-in-Furness in 1902 from American plans. The first entirely British submarine was the A class, which went into service with the Royal Navy in 1905. This submarine was the first to have a periscope. In the 1914-1918 and 1939-1945 wars the Germans concentrated on long-range submarines (U-boats) for attacking merchant convoys

HOW AIRCRAFT LAND ON INVISIBLE AERODROMES

NOT so very long ago it was very dangerous for a pilot to attempt landing on a fog-bound airport, and he had either to fly about until the fog lifted or to try to make for an aerodrome where the weather was clear. If he did not have enough petrol to continue flying, he had to land somehow, even at the risk of crashing.

On page 340 we saw how by using a radar transmitter and receiver an operator on the ground can find the position of any aircraft over his aerodrome without actually seeing it. A further development of radar has made it possible for an aircraft to land on an aerodrome which the pilot cannot see. This is called G.C.A., meaning Ground Control Approach, because the operator on the ground controls the course of the aircraft as it approaches the airport.

On the edge of the airfield is a radar transmitting-receiving set, usually installed in a motor-van so that it can be moved about.

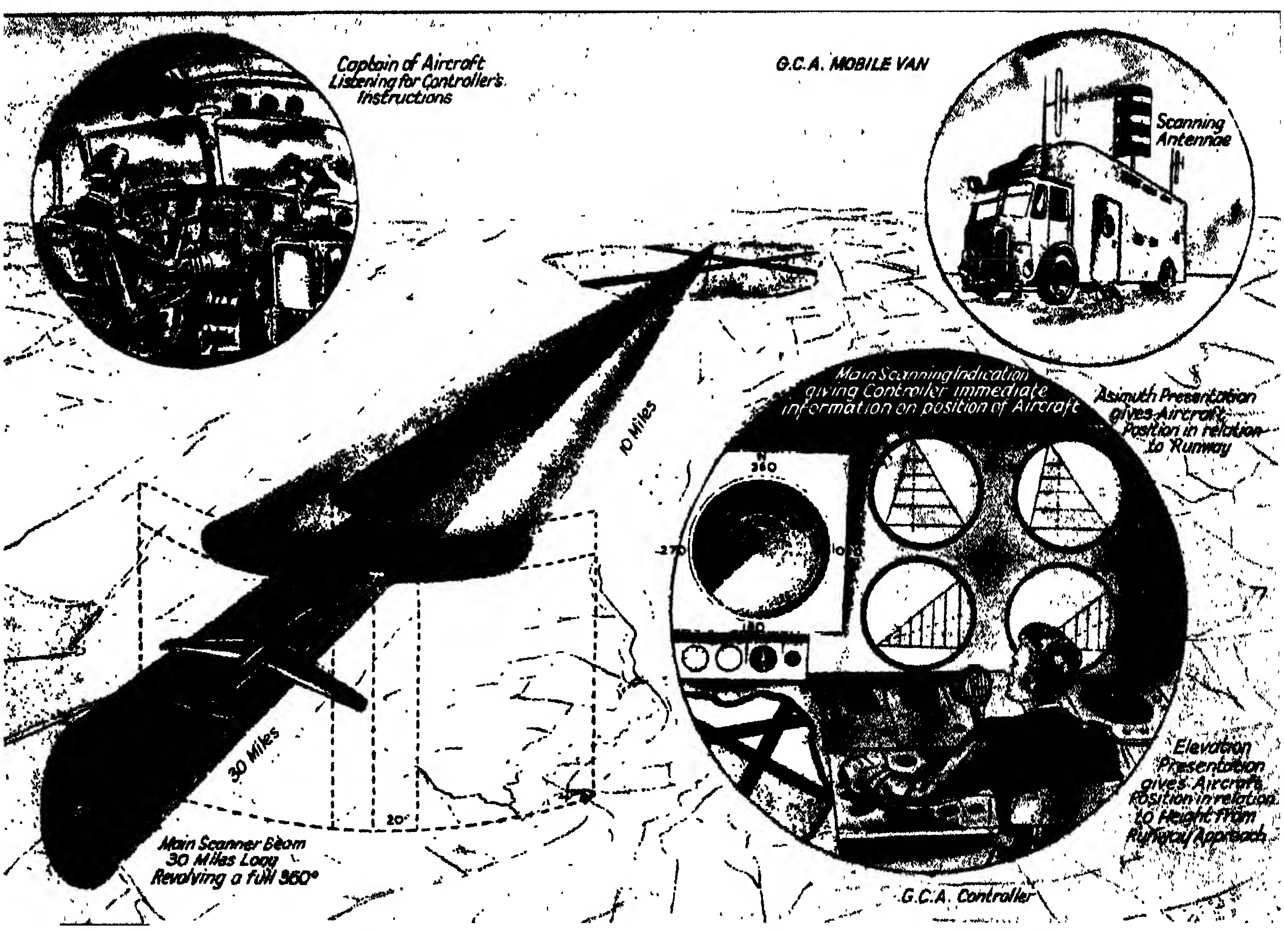
Immediately the weather becomes foggy, the operator in the van begins transmitting radar impulses. The aerial broadcasting the impulses is constantly revolving, and as the transmitter has a range of 30 miles it covers an area of 30 miles all round the aerodrome.

When the radar beam makes contact with an approaching aircraft, the impulses are reflected back from the aeroplane and picked up by the receiving aerial. The received impulses then cause a continuous spot of light to appear on screens, like those of television receivers.

One of the screens has a transparent graph across its face marked in heights by thousands of feet, and from this the operator can see at once how high the aircraft is flying. Another screen is marked round its circumference with the points of the compass and with a number of concentric rings, that is, rings one inside the other and all having the same centre. The rings are spaced to represent a distance of five miles apart, so that from the position of a white blob which the received radar echo causes to appear on the screen, the operator can tell from which direction the aircraft is flying and how far away it is.

The radar operator then gets into radio communication with the pilot and instructs him as to the course he must fly to reach the aerodrome. Thereafter the operator follows the flight of the aircraft as the white blob moves across the screen. When the pilot reaches a certain distance from the aerodrome he is told the direction of the runway on which he is to land, and when to begin gliding in.

By using an illuminated chart of the runway and by watching the moving blob on his radar screen the operator instantly knows if the aircraft is flying on the right course, and if not he radios the pilot to change direction until the blob on the screen is again moving to show that the aeroplane is flying directly towards the runway and at the right gliding angle to land on it. The radar operator thus keeps the aircraft in "view" until the pilot has the wheels of his aircraft safely on the ground and taxis to a standstill



This picture diagram shows you how Ground Control Approach helps the pilot of an aircraft to land on an aerodrome he cannot see. In the top right-hand circle is the radar transmitting and receiving van, and in the bottom right-hand circle we see the radar operator seated in front of his instruments. Extending from the middle of the drawing down to the bottom left-hand corner is a picture of what the radar beam would look like if we could see it. In the top left-hand corner the pilot of the aircraft is listening to the radio messages which guide him to safety in the thickest fog.

OUR DEPENDENCE ON REFLECTED LIGHT

If it were not for the fact that light is reflected, that is, when it strikes a surface it is thrown back in the same way as a ball is bounced off a wall, we should be unable to see anything except what shone by its own light. We read in other parts of this book about how light is reflected, and here we find many more interesting facts about this important scientific principle

WE all know what is meant when we are told that light is reflected. The word "reflect" simply means "bend back," and that is what reflection is. The light strikes a surface and it is at once bent and turned back.

We get a very striking and evident example of the reflection or bending back of light when we take a piece of looking-glass, catch the sun's rays in it, and then turn the glass at an angle so that the rays of light will be directed into the face of some person a distance away. This is a very familiar joke of boys and girls.

Sun-Writing

Sometimes the ray of light from the sun is caught by a mirror near a window on one side of the street and directed across to a window in one of the houses on the other side of the street.

This reflection of the sun's light by a mirror was used for military signalling until the introduction of radio. A mirror which turned at all angles was arranged on a tripod or other stand and the sunlight caught by it was flashed across to wherever it was desired to send a message. By using a code the number and arrangement of the flashes indicated letters and so spelt out a message.

Such an instrument is called a heliograph, that is, an instrument that does "sun-writing." Fifty years ago the heliograph was the chief means of sending messages from one body of troops to another across country where there were no telegraphs. It is sometimes used to-day for signalling between ships at sea, or from shore to ship.

We must be quite clear that a reflection is a very different thing from a shadow. We all know the old Aesop's Fable, which goes by the name of "The Dog and the Shadow." The story tells how a dog, which had stolen a piece of meat from a butcher's shop, was crossing a river on his way home when, as the fable says, "he saw his own shadow reflected in the stream below."

The Other Dog

Thinking that it was another dog with another piece of meat in his mouth, continued the fable, he resolved to make himself master of that also, but in snapping at the supposed treasure, he dropped the meat he was carrying, and so lost all. The moral to this fable is given in the words: "Grasp at the shadow and lose the substance."

The parable is quite interesting and the moral good, but what the dog saw was not his shadow at all, it was his reflection. A shadow, as we have already learned on pages 733 and 734, is merely the cutting off of

This photograph shows the strange effect when light is reflected from a mirror that has a slightly uneven surface. The reason for the distortion is that the rays of light, instead of being reflected regularly as they are from a level mirror, are thrown off at various angles, and so we get an abnormal image

light by an opaque object, so that the outline of the opaque object is cast upon the ground or upon a wall with the light that has not been cut off shining all round.

A reflection is a very different thing. So far from being the cutting off of light, it is the throwing back of light to our eyes.

The reflection of light is really an important fact, not only in science, but in everyday life. Have we ever thought how much we are dependent upon it not only for our happiness and pleasure but for almost everything that we do? If it were not for the fact that light is reflected from the surfaces on which it falls, we should be to all intents and purposes blind.

We should see such objects as the sun, the electric light, the gas jet, the candle flame, and the red-hot poker which shine by their own light. They provide light and the rays would pass direct to our eyes. But we should see nothing that did not itself give out light.

We should be unable to read this book or see the pictures in it; we should fail to see our friends, or, indeed, anything that was not luminous. It would be a dark, blank world to us. Our eyes would be practically useless.

We have already seen on pages 621, 675 and 1013 how the light is reflected from plain or flat mirrors and also from curved mirrors. We have seen, too, that a rough surface reflects or bends back the light, but does it in all directions, so that the light is diffused. It is because of this that a room is light enough to see and work and read in, although the sun does not shine directly into the window.

Perhaps, as in the case of many offices, the sun is shining in the opposite direction from the window of the room, but the rays are reflected or bent back by the wall opposite, which may perhaps be covered with shiny white tiles, to reflect more evenly and directly. Then the rays that come into the room strike all sorts of rough surfaces, and so the light is diffused and nearly everything in the room is illuminated.

A smooth sheet of water, like a silvered glass mirror, reflects the light directly, so that we see an image of what is before the mirror.

But if the surface of the glass or the water is not exactly even then some strange effects in the way of reflection are obtained. We can see this in the case of the water on page 1212, where, owing to the rippling of the surface by the wind, the masts and sails and other parts of the boats in the reflection appear all zigzag.

The same thing is seen in the case of mirrors which are not quite level. One or two examples are given on these pages. It wants very little inequality of the surface to produce the most grotesque and amusing effects. One does not need to have very much scientific knowledge to know this. Even the showman at the fair is aware of the fact when he invites you into his Hall of Magic Mirrors, in which you see yourself distorted in all sorts of ways, according to the particular mirror in which you are looking at the time. Part of you may be lengthened while another part is shortened, or some section of your body may be inverted while the other is the right way up.

While the image in a plain or level

Many images seen when we look sideways into a mirror

This diagram shows why we see many reflections when looking into a mirror at an angle. The object is reflected first by the front of the mirror, then by the back, and then at an angle to and fro between front and back till all the light is absorbed

The multiple reflections when an object is viewed in two mirrors placed at right angles

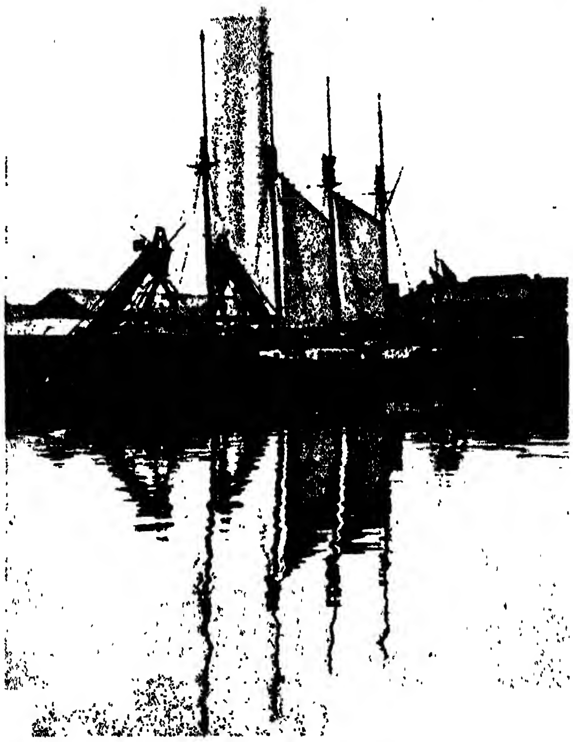
Two amusing examples of the strange reflections that are given by mirrors when their surfaces are slightly irregular. Any curvature will cause distortion, often with disconcerting results to the person reflected

mirror is not distorted it must be remembered that it is not an exact counterpart of the object producing it, for the right hand of the object becomes the left hand of the image

We soon recognise this if we hold this printed page before the looking-glass. The letters are the right way up, but they are reversed. If we write a word in ink and blot it quickly with a clean piece of blotting-paper it will appear reversed on the blotting-paper.

Now, if we hold the blotting-paper up before a mirror the writing will again be reversed, and we shall be able to read the word correctly in the mirror.

In a really level mirror with no inequalities the reflection is almost perfect, and both men and animals have before now run into mirrors, the edges of which were concealed, not realising that there was a mirror at all. They were unable to see the mirror because everything before it was reflected so perfectly that it gave the illusion not of a glass surface, but of an open space. It is because of this reflection



This photograph shows the effect upon a reflection in the water when the surface is slightly ruffled by the wind

that large mirrors in a hall or room always make the room appear much bigger than it really is.

As a proof of how confusing, sometimes, the reversal of objects reflected in a mirror is we can carry out one or two experiments.

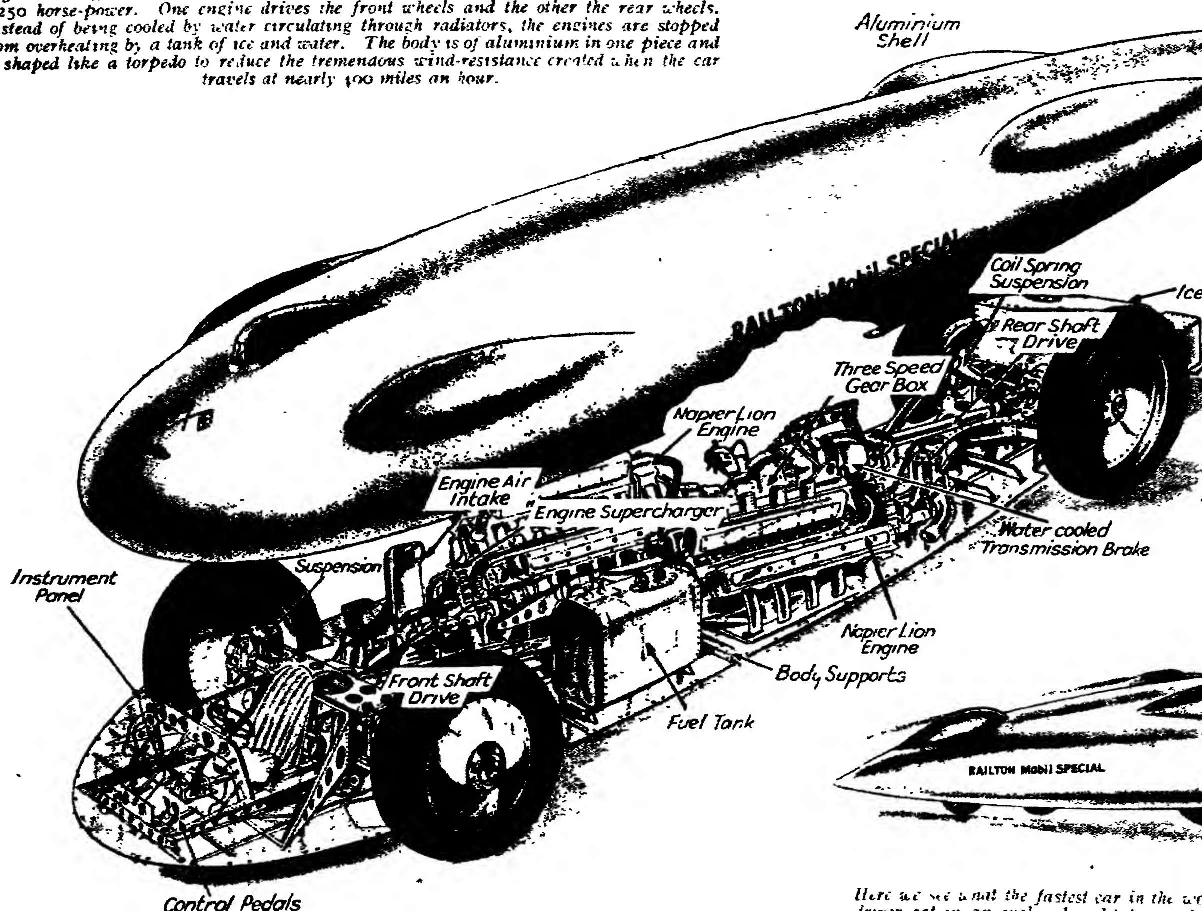
Standing before a mirror with a piece of paper and a pencil, we try, without taking our pencil off the paper, and looking only into the mirror and not at our hand, to draw a square or oblong with its two diagonals.

When we have made the rectangle we shall almost certainly carry the pencil in the wrong direction for the diagonal. So that we may not unconsciously see our hand, we should get a friend to hold a paper under our chin, shutting off the view, so that we see only the reflection in the mirror.

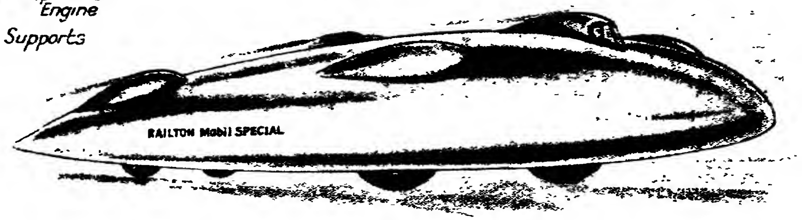
We should try also by following only the reflection of our hand in the glass to write or print our name on a piece of paper so that it appears the right way up as we read it in the reflection We shall find this exceedingly difficult.

CAR THAT SET UP A LAND SPEED RECORD OF 394 MILES AN HOUR

The Railton Mobil special was named after its designer, R. Railton, and was built in 1938. It weighs three tons and is powered by two Napier Lion aeroplane engines each of 1,250 horse-power. One engine drives the front wheels and the other the rear wheels. Instead of being cooled by water circulating through radiators, the engines are stopped from overheating by a tank of ice and water. The body is of aluminium in one piece and is shaped like a torpedo to reduce the tremendous wind-resistance created when the car travels at nearly 400 miles an hour.



The first motor speed record was set up in 1898 by a French car at a speed of 39 m.p.h. Soon afterwards Henry Ford travelled at 98 m.p.h on the sands at Florida, and by 1914 a speed of 124 miles an hour had been reached. In 1925 Malcolm Campbell set up a record of 150 miles an hour, and the following year Parry Thomas drove at 170 miles an hour on the Pendine Sands, Wales. In 1927 Henry Segrave set up a new record of 203 miles an hour at Daytona Beach, Florida, and two years later in the Golden Arrow travelled at 231 miles an hour. In 1935 Malcolm Campbell reached 300 miles an hour. In 1938 Captain Eyston's seven-ton Thunderbolt was driven at 345 miles an hour and a few days later John Cobb raised the record to 350 miles an hour. John Cobb made a new record in 1939 with 369 miles an hour, and then beat this record in 1947 at a speed of 394 miles an hour.



Here we see what the fastest car in the world looked like when travelling at speed. The driver sat in an enclosed cockpit mounted well forward of the front wheels to give him a good view. The two pear-shaped blisters on each side of the car's body are to allow room for the wheels, which are almost completely enclosed to reduce air resistance.

This picture diagram shows you the inside of the Railton Mobil Special racing car in which the late John Cobb set up a land speed record of 394 miles an hour on September 16, 1947. The record-breaking run was made over a measured mile on the Bourneville Salt Flats, Utah, U.S.A., and for part of the record run the car travelled at 415 miles an hour. The actual course for the run was 12 miles long, and when setting up his record Cobb needed 5 miles to work up to full speed for the measured mile and another 5 miles to slow down and stop after travelling at 394 miles an hour. During the record-breaking run, each of the four wheels of the car turned 3,000 times a minute, and completely wore out the tyre treads

WHY A HAMMER DRIVES A NAIL INTO WOOD

We drive a nail into wood by striking it sharply on the head with a hammer. The hammer possesses what we call kinetic energy, that is a power to do work due to its mass and its speed or velocity. The work it can do is equal to the work done in imparting this speed to the hammer's mass. Each blow enables the hammer to overcome through a short distance the great resistance which the wood offers to the entrance of the nail. The bench in the first picture prevents the wood from moving. But if we try to drive in a nail as in the second picture, even if the other end of the plank be fixed, it is exceedingly difficult to do so. The wood can bend and the nail is able to move through some distance without meeting with as much resistance as the wood offers. If, however, as in the third picture, a block is held under the end of the plank, the movement of the wood is stayed and the kinetic energy of the hammer can all be expended in driving the nail home. This is why a carpenter often holds a block under a piece of wood that can move while he is hammering

THE WONDER OF THE BLIND SPOT IN YOUR EYE

HERE is an interesting experiment which you can carry out as you have this book in your hand. Look at the picture which shows a mother and child in the country. Closing your left eye, hold the picture about two feet from your face. You will see both the mother and the child.

Now, keeping your left eye closed and gazing all the time at the child, bring the page slowly near to your face. At a certain point the mother will suddenly disappear from the picture, and she will be absent for some little time; but as you gradually bring the picture nearer to your face the mother will appear again.

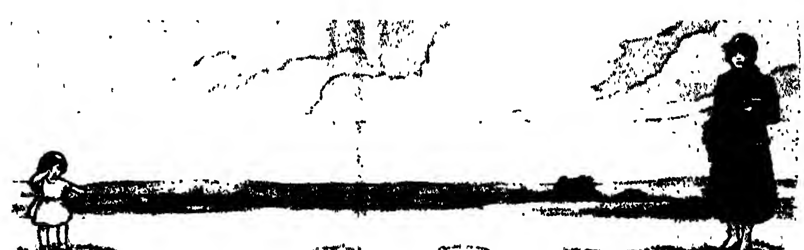
Next try another experiment of a similar kind. This time close your right eye and hold the picture as before about two feet away. Look at the mother as you bring the page nearer and nearer to your face. At one point the child will disappear, and will only reappear after you have brought the picture several inches nearer.

What is the explanation of this mystery? Well, every one of us has in his eye a spot which is blind, and when the rays of light from any object which we may be looking at fall upon this spot no message is sent to the seeing part of the brain, and consequently we see nothing of the object.

The blind spot is that part of the eye where the optic nerve from the brain enters and spreads out into a thin film of nerve-fibres forming the innermost layer of the retina, or curtain at the back of the eye. If a small beam of light be shone into a man's eye and allowed to fall on the blind spot, he will receive no sensation of light; for, strange as it may seem, the optic nerve itself is not sensitive to light.

It is when the light from the child or the mother in the picture falls upon this blind spot that the image disappears. The usual method of carrying out the experiment is by drawing an X and an O, but by giving figures of human beings it becomes more interesting.

In the ordinary way we do not notice that we have a blind spot in each eye, because, as must often happen, when an image by falling upon it disappears from one eye, the other eye records the image, and so the gap in our seeing is filled up.

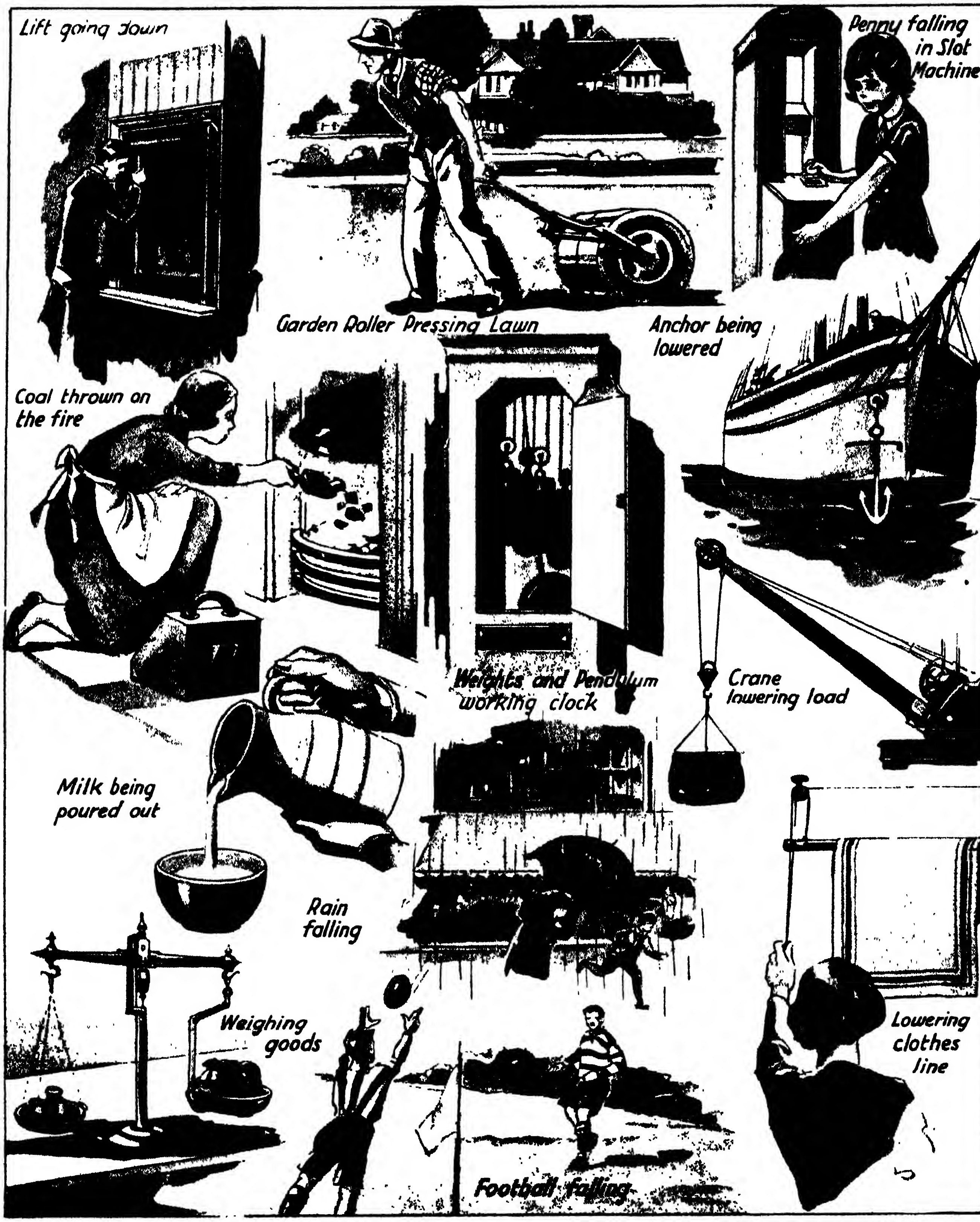


Close your left eye and holding the page about two feet away look at the child. The mother will also be visible. Now bring the page slowly nearer to your face and at one point the mother will disappear altogether

If the optic nerve itself is not sensitive to light, we may well ask what part of the eye it is that receives sensations of light. Well, men of science believe it is the outer layers of cells in the retina which are shaped like little rods and cones that are stimulated by light, and then the sensation is passed on to the optic nerve which thereupon carries the message to the brain.

Another curious fact about our sight is that the impression made by light upon the retina lasts longer than the duration of the light itself. Thus a flash of lightning is instantaneous, but we see the flash for about an eighth of a second. The cinema depends upon this fact for its success (see pages 6 and 7).

WAYS IN WHICH GRAVITATION IS A HELP



Gravitation, or the pull of the Earth, is useful in many ways, some of which are shown on this page. Often we want things to fall and it is gravitation that enables them to do so. Putting coal on the fire, lowering the lift, dropping a penny into the slot machine, lowering a load by a crane or the clothes on the clothes-line, and pouring out a liquid are all examples of this. It is gravitation that makes some clocks go by causing the weights to descend and the pendulum to move. By means of gravitation we can measure the mass or quantity of a substance by weighing it, and it is gravitation that makes the garden roller press on the earth and level the lawn.

WAYS IN WHICH GRAVITATION HINDERS US

Gravitation is not always a help. It is because of gravitation that we fall down, that an aeroplane crashes when something goes wrong, and a chimney falls when it is blown from the roof. Soot falls because of the pull of gravitation. If we load a bookshelf with heavy books it sags in the middle because of the pull of gravitation on the unsupported part, and the same thing is true of the sagging of telegraph and other electric wires. Because of this sagging more wire must be used. Gravitation also makes us bend when we carry heavy loads, and it causes lorry wheels to sink in the mud. Because of gravitation it is a lot of trouble to raise a heavy weight like a safe.

THE STRANGE ANTICS OF A BALL OF FIRE

From time to time a strange form of lightning is seen. It appears as a ball of fire and travels slowly, constantly changing its direction. In this picture we see the course of one of these fireballs, known as globe lightning. It originated as one ball, but on touching the ground split into two. These rose and while one went down the chimney of a house and exploded, doing great damage, the other followed a more erratic course. It went down the chimney of another house, crossed a room in which were a man and a child, doing no harm to either and then, making a small hole in the floor, went through into the chamber beneath, used as a sheep-fold. The lambs started jumping about, and five older sheep were killed. The shepherd's son at the door was not injured. The ball then passed out at the doorway

A VERY MYSTERIOUS FORM OF LIGHTNING

There is a form of lightning which is very mysterious and about which little is known. It is called globe lightning, and appears in the form of a ball of fire which travels about in the most eccentric manner, sometimes proving quite harmless and at other times doing immense damage. Science cannot explain globe lightning, but here are some facts about its appearance and work

Of all the various forms of atmospheric electricity, globe or ball lightning is the most difficult to explain. It is much rarer than the ordinary lightning, and its behaviour is so strange that for a long time men of science refused to believe that it was anything but a figment of the imagination. Frightened people, they said, upset by a sudden flash of lightning, fancied they saw a fireball, and their imaginations supplied the rest of the story.

But there have been too many well-authenticated records of globe lightning for the phenomenon to be dismissed in this way. All we can say is that it does not occur very often, and that while other forms of lightning can be reproduced on a small scale in the laboratory, globe lightning cannot be reproduced artificially.

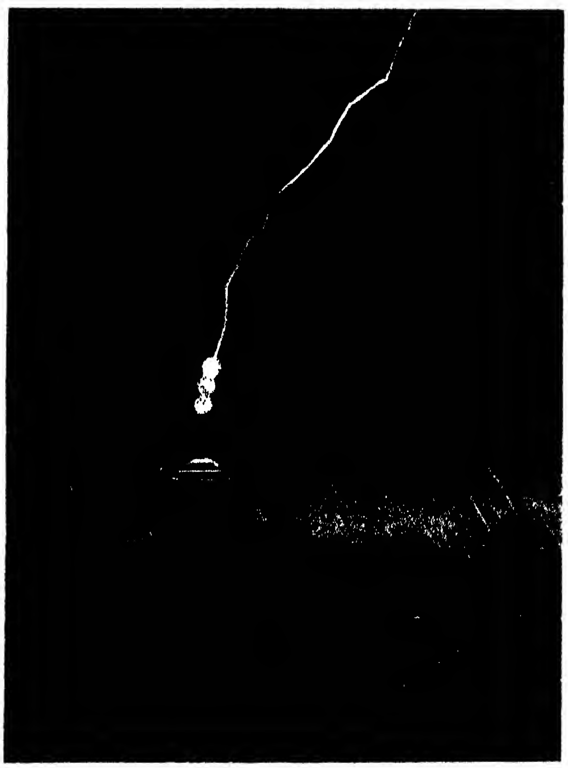
When the fireball appears one can never say what it is going to do. It generally moves very slowly, so that its course can be watched. It will enter a house by the chimney or a window or door, will pass from room to room, either through the door or by making a hole in the wall, will descend or ascend and will pass out and disappear in the open air.

On the other hand it may explode, doing great damage and destroying life. It may travel over a person's body, leaving him unharmed or injured. It may pass through a party without doing any harm, or at any rate more than scorching the clothes of the people, or it may kill the group. It seems to be more dangerous to animals than to human beings.

Monsieur Camille Flammarion, the great French scientist, tells us that in October, 1898, at Marseilles, a fireball made its appearance in a room and advanced towards a young girl, who was seated at a table, her feet hanging down without touching the floor.

The luminous globe moved along the floor in the girl's direction, began to rise when near her, and then travelled round and round her in a spiral, darting off towards a hole in the chimney made for a stovepipe, and closed up with glued paper. It went through the paper, travelled up the chimney and on emerging into the open air exploded with a crash which shook the entire house. As M. Flammarion says, "It was a case of coming in like a lamb and going out like a lion."

But fireballs are not always so harmless. In another case during a violent storm a globe of fire suddenly appeared at the top of a poplar tree. It descended, branch by branch, then travelled down the trunk and moved along the courtyard of a farm very slowly. The spectator who witnessed the occurrence says: "The ball seemed almost to pick its way between the pools of water. It came up to the door of a stable, where stood two children, and one of them was bold enough to touch it with his foot. At once there was a terrible crash which shook the entire farm to its foundations. Strangely enough the two children, though thrown to the ground, were uninjured, but eleven animals in the stable were killed."



The strange appearance of three fireballs on the tower of the electric power station in Paris

In another case a fireball came down the chimney into a room in a house at Salagnac, in France, where were a child and three women. None of these was harmed. Then it rolled along the ground into an adjoining kitchen, and passed near the feet of a young peasant standing there. Again, it was harmless, and after passing into still another room it disappeared, leaving no trace of its journey. It was found afterwards that it had gone into a little stable close by and killed a pig. Curiously enough it had passed through the straw without setting this on fire.

On March 6th, 1894, M. Dandois, professor of surgery at the University of Louvain, was returning from a neighbouring town after seeing a patient when the sky suddenly darkened and a ball of fire appeared which struck the surgeon and hurled him over a ditch into a field, where he lay for some time unconscious. On regaining his senses he found that he was uninjured save for a numbness in one arm and leg.

On August 19th, 1900, a number of people were in a room in a château at Maintenay, when a violent storm came on. Suddenly a globe of blue fire about the size of a baby's head appeared in the midst of the eleven people in the room. It crossed the chamber, touching four people on its way, but none of these was injured. Then there was a terrific explosion and the fireball disappeared through an open door in front of the great staircase. Apparently no harm at all was done on this occasion.

Fortunately globe lightning is rarely seen in England, but many cases are recorded from France. There was, however, one very alarming instance of globe lightning in London when a so-called "fireball" nearly hit St. Paul's Cathedral on the night of May 23rd, 1933. A policeman was on duty near the West Entrance when, during a thunderstorm, a ball of fire with a tail three or four yards long came rushing out of the sky at tremendous speed, exploded and knocked the constable senseless.

THE CHEDDAR GORGE CARVED OUT OF SOLID ROCK

England is a country remarkably rich in beautiful scenery, but it does not possess those vast monuments of Nature which stagger the imagination and cause a feeling of awe by their sheer immensity. Great mountains like the Himalayas, the Andes or even the Alps, and great rivers like the Amazon, the Mississippi and St. Lawrence are unknown in England. But there is one natural feature which has a tremendous effect upon the beholder, and that is the Cheddar Gorge, an enormous cleft carved in the bare limestone hills of Somerset. It is perhaps one of the most impressive of all the natural features to be seen in England, and this photograph gives some slight idea of its magnificence and majestic appearance. It used to be thought that the Cheddar Gorge was the result of some great natural upheaval such as an earthquake, but we now know better. The picture on the opposite page shows how the Cheddar Gorge was formed

HOW THE CHEDDAR GORGE WAS FORMED FROM A CAVE

USING AIR TO DIG OUT COPPER ORE

Miners to-day have enormous advantages over their predecessors, for with mechanical diggers and pneumatic tools their labour is greatly lightened. Such tools are coming more and more into general use and, in addition, modern methods of getting the material out of the mine to the surface are a very great improvement on the old methods of dragging or carrying it to the shaft by man or horse power. In many mines there are underground electric railways and electrically-drawn cages to bring the workers and the material to the surface. This photograph shows a miner at work with a pneumatic drill in a German copper mine half a mile underground. The type of pneumatic drills used in mining is described in page 537.

THE WONDER OF THE STEAM TURBINE

The turbine engine is a marvel of efficiency. Instead of striking on a piston and driving it to and fro in a cylinder, the steam in a turbine engine plays upon thousands of metal blades fixed in rings round a rotor. The rotor works in a cylindrical casing, which also has thousands of blades arranged in rings. The steam plays upon the blades of the rotor and whirls it round at an enormous speed, being thrown upon each ring of blades in turn by the blades of the cylinder. Here we read of the romantic story of the turbine

THE invention of the turbine engine by Sir Charles Parsons marked a new era in the history of the steamship. Although it was ordinarily used for driving electric generators, the inventor was convinced it could be adapted with advantage to the driving of steamships, but no one would listen to him.

So he quietly built a little ship of 44½ tons burden, fitted it with turbine engines, and took it to Spithead when the great naval review to celebrate Queen Victoria's Diamond Jubilee was to be held. Royal and distinguished persons from all parts of the world were present.

Suddenly a little craft was seen racing up and down between the lines of warships. People were staggered and the officials shocked. How dared this small boat—100 feet long and 9 feet broad—go on forbidden water? A swift torpedo-boat was sent to chase her and order her from the course, but this fast boat of the Navy could not get anywhere near the little craft. It was the *Turbinia*, and she simply laughed at her pursuer. It was a dramatic demonstration of the power and suitability of the turbine for the propulsion of ships.

The engines of the *Turbinia* developed 2,000 horse-power and attained a speed of 34 knots, that is, 39 miles an hour. There was none of the usual noise and vibration caused by ordinary engines, and everyone was impressed with her performance. The triumph of the turbine was assured.

The British Admiralty at once ordered a number of destroyers to be fitted with turbine engines, and when these were launched they attained the previously unheard-of speed of 37 knots.

In 1904 the first turbine liners were built, and a year later the Cunard Company adopted turbines for their Atlantic greyhounds, the *Mauretania* and *Lusitania*.

The turbine has immense advantages over the older reciprocating steam-engine. Its action is direct, that is, the steam produces rotary motion immediately and not a to-and-fro action, as in the older engine, which has to be transformed with a certain loss of power and speed into rotary motion by means of a crank.

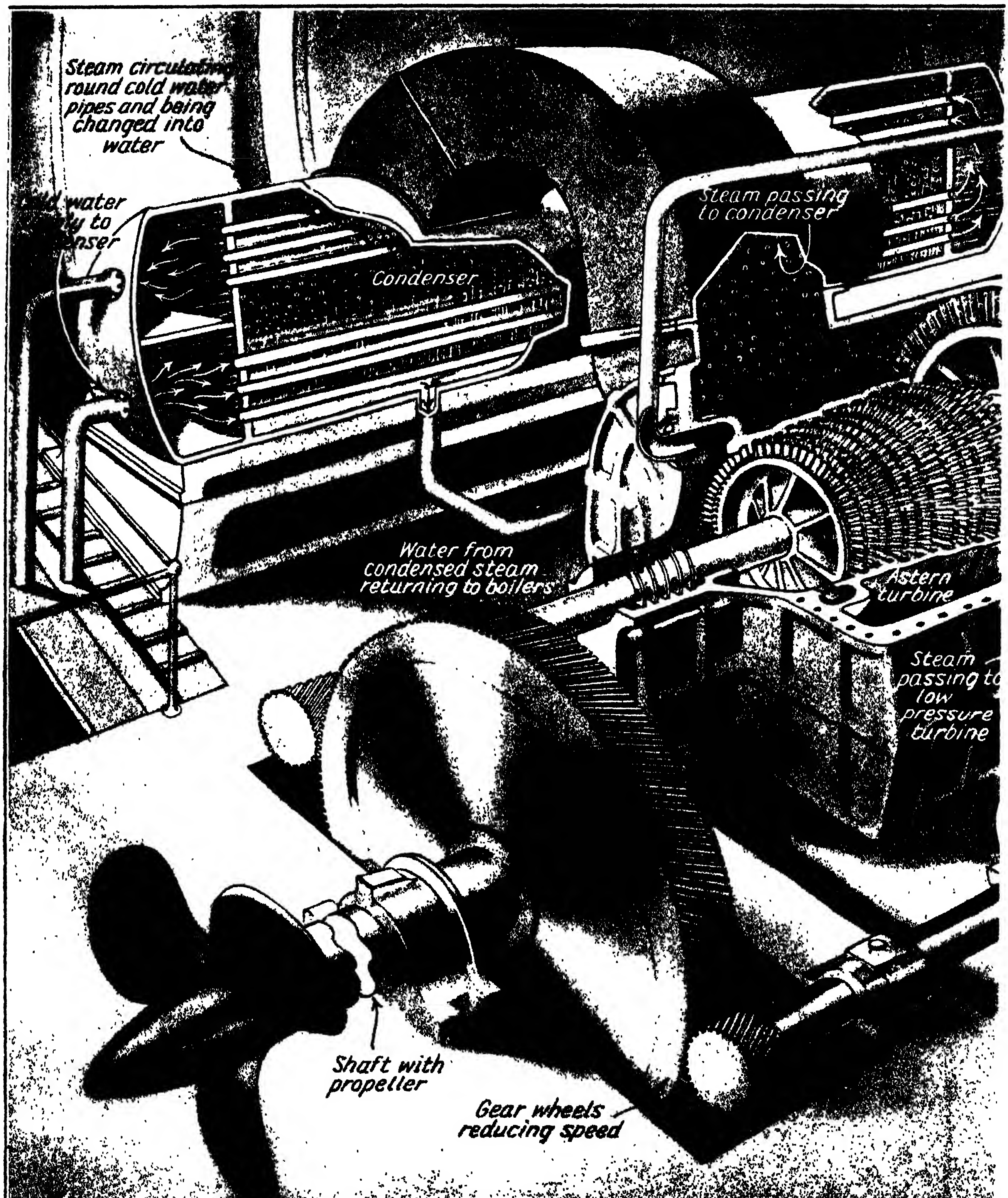
It is less than half the weight of a reciprocating engine of equal power, occupies much less space, uses far less steam, has fewer working parts, is practically without vibration, has fewer rubbing surfaces to cause friction, and requires much less attention. One man, for example, can look after several large turbines.

The way in which the turbine works can be clearly seen in the large double-page explanatory drawing given on the next two pages.

It is no exaggeration to say that the turbine wrought a revolution in the steamship world, and it is a matter of satisfaction that, like the first practical steam engine and the first locomotive, it is an English invention.

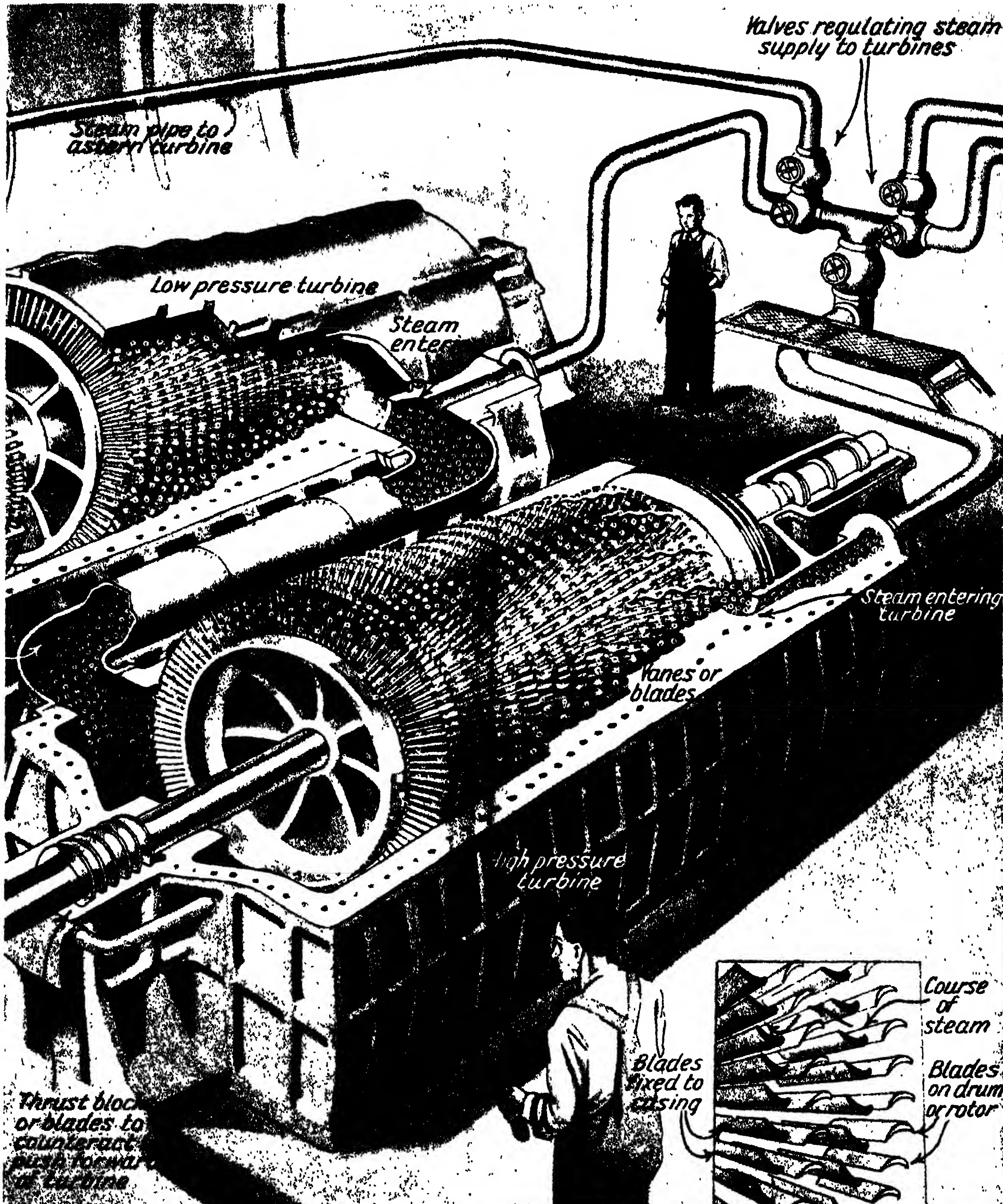
Here is part of the little turbine steamer *Turbinia*, the first vessel to be driven by turbine engines. It is now in the Science Museum at Kensington, and the photograph is reproduced by permission of the Director. The hull has been cut away to show the engines inside

HOW A TURBINE IS DRIVEN BY STEAM



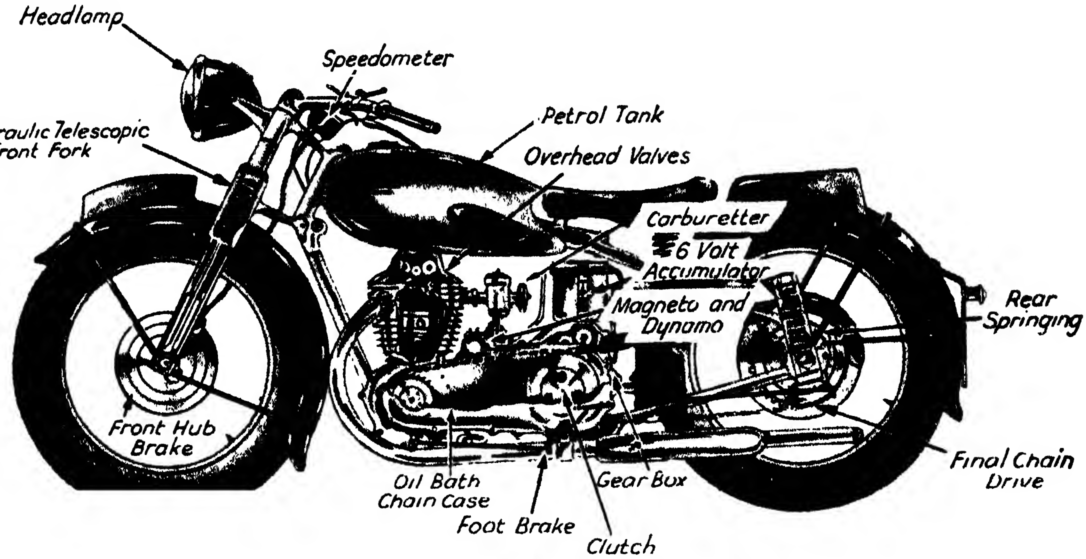
The invention of the steam turbine wrought a revolution in the driving of steamships. In these pages Mr. L. G. Goodwin shows in simplified form how the turbines of a steamship work. The supply of steam from the boiler is regulated by valves worked by small wheels, as shown on the right. The steam enters the turbine and strikes upon thousands of little vanes or blades inserted in rings round a rotor or drum These vanes are not all of the same length. They get longer and longer, the reason being that as the steam in its passage loses some of its force, it is given a larger surface to play upon by having longer blades, and so can produce the same effect. The steam is directed upon each ring of blades on the drum by rings of blades fixed round the inside of the casing. In the bottom right-hand picture we see how this happens. In the picture of the high-pressure turbine the top of the casing has been removed to show the drum with its blades. The tremendous power of the steam acting upon thousands of blades tends to push the turbine forward. To counteract this some steam is admitted through a pipe to the front of the turbine, and plays upon a number of thrust blocks, in the

PLAYING ON MYRIADS OF LITTLE VANES

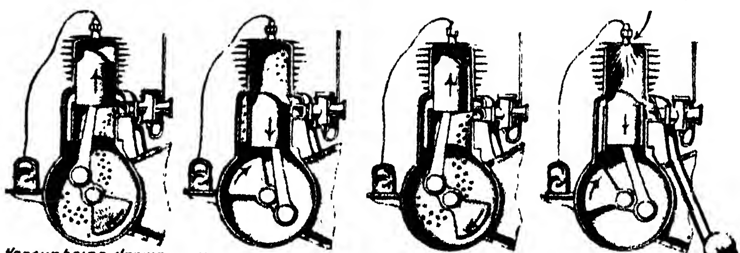


other direction, thus balancing the thrust forward. From the high-pressure turbine the steam now passes to a low-pressure turbine, where the whole process is repeated, and it then goes to a condenser where cold water circulating in pipes condenses it into water, which returns warm to the boiler to be used again for the production of steam. Of course, the turbine turns far too fast to be used directly in rotating the screw propeller, and therefore, by a series of gear-wheels, the speed is reduced, so that the shaft bearing the propeller will turn at a safe speed. The propeller is shown in the picture, but, of course, the shaft connecting this with the turbine is of great length, and runs in the ship in a shaft tunnel as seen on pages 82 and 83. When it is desired to drive the ship backwards, the high- and low-pressure turbines are stopped, the steam supply to them being cut off. Steam is then admitted to the astern turbine, which rotates the other way and reverses the propeller. When this is being done the high- and low-pressure turbines rotate idly in the opposite direction, moving in unison with the astern turbine. Of course, large ships have more than one set of turbines

HOW A MOTOR-CYCLE IS MADE TO GO



This picture diagram shows you what makes a motor-cycle's wheels go round. Petrol from the tank flows into the carburetter, where it is mixed with air and drawn into the cylinder. There an electric spark explodes the vapour, which expands and forces down the piston. The drawings on the right show in simplified form what happens in the cylinder. The petrol and air vapour enter the lower part of the cylinder when the piston goes up, and when the piston goes down the mixture flows through the transfer port into the upper part of the cylinder. The piston is again forced upwards, and the petrol vapour is compressed between the piston head and the top of the cylinder. Compressing the vapour raises its temperature so that the mixture becomes highly explosive. At the moment of greatest compression, an electric current sparks across the gap of a plug on top of the cylinder and explodes the vapour to force the piston down. The bottom of the piston is connected to a shaft by a rod, so converting the up-and-down motion of the piston into the round-and-round motion of a wheel. Fixed to one end of the shaft is a toothed wheel over which passes a chain turning another toothed wheel in the gear box ; the gear is in turn connected by chain to the rear, or driving, road wheel. Consequently as the piston keeps moving up and down in the cylinder so the road wheel revolves. The electric current creating the spark in the cylinder is generated by a dynamo driven from the engine shaft. Waste gases left in the cylinder after each explosion of the vapour are led through an exhaust pipe and pass out into the air. A twist grip on the handlebar controls the amount of petrol vapour that enters the cylinder and, therefore, the power developed by the engine. A lever outside the gearbox changes the gear, that is, puts into combination different-sized cogwheels to give various road speeds from the constant speed of the engine. A motor-cycle has two brakes : one, controlled from the handlebars, acts on the front wheel; the other, operated by a foot pedal, acts on the rear wheel. The fork supporting the front wheel moves against springs in an oil-filled cylinder ; this prevents excessive vibration when the motor-cycle is travelling at high speed or over rough ground.



Vapour being drawn from carburetter — *Vapour going to top of cylinder* — *Piston compressing vapour* — *Piston forced down*

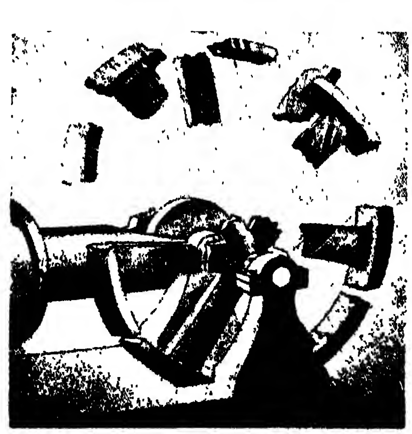
WHY A FLYWHEEL SOMETIMES BURSTS

We sometimes read in the newspapers that at a certain factory a flywheel has exploded and done a great deal of damage, sometimes injuring or killing a number of workpeople. What has really happened is that the flywheel has burst, not exploded.

There is, of course, nothing to cause an explosion, but sometimes when there is a flaw in the metal of which the flywheel is composed, the centrifugal force is so great, as the wheel goes round faster and faster, that it overcomes the other force of cohesion which holds the particles of metal together, and part of the wheel flies off at a tangent. Then, when the wheel is once broken, centrifugal force causes other parts to fly off, and owing to the speed of the wheel these do great damage.

Generally flywheels are made so well that the cohesive force holding their particles together is greater than the centrifugal force, and so they remain intact. Any wheel, however, if it were revolved rapidly enough might be broken by centrifugal force.

Wheels are always tested for the speed at which they are to run, and only when there is a flaw does an accident happen



A flywheel comes apart while rotating.

In all rotating objects there is a contest between centrifugal force and some other force that is holding the objects together. It is fully explained on page 61 that on the rotating Earth itself centrifugal force is overcome by the power of gravitation Were it not so, nothing could remain on the Earth's surface. If the Earth rotated faster and faster there would come a time when the centrifugal force would be greater than the power of gravitation, and the Earth itself would break up just as a flywheel does when centrifugal force overcomes cohesion

All the things round about us are subject to various forces and their present state is the product of these forces If a body is at rest then there is an equilibrium between the various forces acting upon it. The book on the table, for example, is being pulled down by gravitation but pushed up by the reaction of the table It is also tending to fly off the rotating earth by centrifugal force, but the balance of these forces keeps the book at rest.

IF A COMET STRUCK THE EARTH

Comets are among the strangest members of the solar system. They are curiously shaped, and travel in different kinds of orbits. At one time they gave rise to a great deal of fear, people thinking their appearance had something to do with forthcoming events on the Earth. We know better than that now. We read something about the nature of comets on pages 599 to 601, and here is some further information about these celestial visitors, many of which visit us only once and never return

PEOPLE used to be very frightened when they saw a comet growing bigger and bigger, that is, getting nearer and nearer to the Earth, in case it might strike our world. They believed that if this happened the Earth would be burnt up, and that would be the end of our planet, and all its life. No wonder they were frightened when they saw a comet!

As a matter of fact, the Earth has more than once passed through the tail of a comet. This happened in 1861, and all that was seen or experienced was a delicate misty gleam in the sky, and a number of meteors or shooting stars.

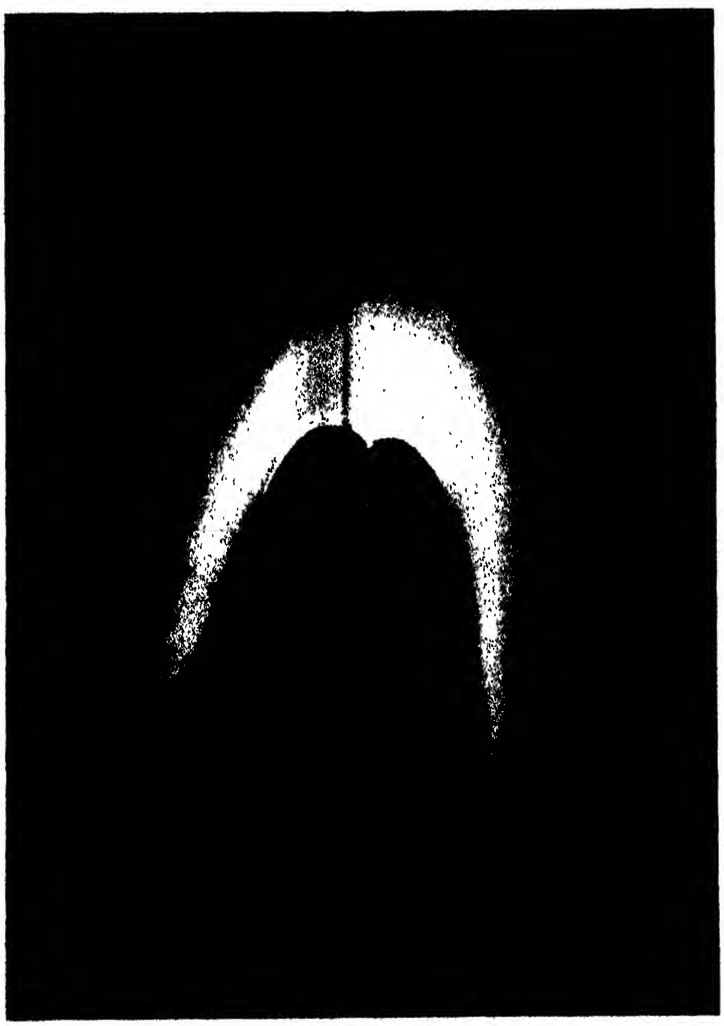
But suppose the Earth were to come into collision with the head of a comet. What would happen then? It is quite a possibility, for the orbits of some of the comets touch that of the Earth at a certain point, and one day Earth and comet may arrive at the junction together.

The Mysterious Head

It is impossible to say definitely what the result would be, for we do not yet know with certainty what the head of a comet is really like. If it consists of very small particles, as many astronomers believe, then the only result would be an unusually fine display of meteors, the fragments being burnt up as they rushed through the Earth's atmosphere. Of course, if the fragments weighed some tons, then the bombardment would be serious for the parts of the Earth which were struck, but the general opinion of astronomers is that the fragments forming the head of a comet are mere pinheads, so we have nothing to fear. In any case, a collision of this sort is not likely to occur more than once in about fifteen million years.

It has also been suggested that if a comet were to strike the Earth our atmosphere would be poisoned by the gases in the fragments of the tail. But owing to the low density of the comet's tail we need not fear that sufficient poisonous gas would come into our atmosphere to do any harm.

Another fear which has been expressed is that a comet might fall into the Sun, and so increase the solar heat that we should be scorched to death. But here again we need have no fear. Professor Charles Young has pointed out that if a comet with a mass equal to one 100,000th of the Earth's mass were to strike the Sun's surface with a speed of 400 miles a second the energy of impact, converted into heat, would generate about as many calories of heat as the Sun radiates in eight or nine hours; but it is most unlikely that all this extra heat would be effective in an instant, or even in a single hour.



The head of the Great Comet of 1861, which was seen clearly in the British Isles after passing from the southern hemisphere into the northern. The head of a comet consists of the coma or hazy cloud of faintly luminous, transparent matter and the nucleus or central condensation, a bright more or less star-like point near the centre of the coma

A Solar Flash

The particles of the comet would pierce the photosphere, that is, the sheet of luminous clouds enveloping the Sun, and set free their heat mostly below the solar surface. The Sun's diameter would probably be expanded very slightly, adding to its store of energy about as much as it expends in the ordinary way in a few hours. If astronomers were watching the Sun through the telescope they would probably see a flash of some kind, but nothing would happen to inconvenience the watcher.

We can all go to sleep quite comfortably, without worrying, as did our forefathers, about what would happen if a comet struck the Earth or the Sun. Unless we were astronomers we should probably be quite unaware of the fact.

The orbits or paths of the comets are very unlike those of the planets. Some of these

comets come into our view again and again over varying periods of years. Encke's Comet, for instance, returns at periods of 3 3 years, whereas Halley's Comet returns in about 75 years.

Some comets in their journey travel out beyond the orbit of Neptune, and they are known as Neptune's family of comets. There are five in that family. Then there are the comets, about fifty in number, which return at periods ranging from three to eight years, and are spoken of as Jupiter's family of comets, because they do not travel far beyond the orbit of Jupiter. The planets Saturn and Uranus also have comets associated with them.

Three Kinds of Orbits

Now one of the strangest things about comets is that they travel in three different kinds of orbit, and all of them are geometric figures, which are known as sections of a cone.

If we cut off the top of a cone horizontally, the base of the part cut off is a circle. A cut made obliquely, however, from side to side yields an ellipse, and the ellipse is nearer to or farther from a circle as the cut is made at a lesser or greater angle.

But if we cut the cone through from the side to the base, the cut being made parallel to the opposite side, we get a figure which is known as a parabola. On the other hand, if we cut the cone through from any point in the side and make the cut parallel to the line of the cone's axis, we get a figure which is known to mathematicians as a hyperbola. All these are shown in the bottom picture on page 600, where many interesting facts about comets are given.

Now no comets travel round the Sun in a circle, but all those which we see again and again travel in ellipses. Certain comets, however, which come to us, follow paths which are parabolas, while others travel in orbits that are hyperbolas. Those which travel in these parabolic and hyperbolic orbits are just stray visitors. We never see them again, and the reason is clear.

In the case of an elliptical path the lines of the orbit meet, but in the case of those paths which are hyperbolas and parabolas, the lines never meet. We therefore see the comet approach the Sun, travel round it and start on its journey away, and then we never see it any more.

Donati's Comet, as it appeared in the sky in 1858. The length of its tail was at one period 51 million miles

comet which appeared in September, 1908. From a photograph by Professor E. E. Barnard, reproduced by courtesy of the Royal Astronomical Society

Strange Ideas

Why there should be these different paths for comets is not altogether clear, but we know that if a comet is travelling in a parabola the smallest retardation due to the comet coming near a planet would change the parabolic path into an ellipse, while the slightest acceleration would make it a hyperbola.

In the old days men of science as well as the unlearned had strange ideas about the comets and their orbits. At one time comets were regarded as material thrown out from the Earth, probably through volcanoes, and the great Kepler himself believed comets to be alive. In 1577 Tycho Brahe proved from actual measurements that the great comet of that year was farther from the Earth than is the Moon.

The period of visibility of a comet does not usually last more than a few months, but in recent years the average duration of the period during which a comet is seen has been lengthened a good deal owing to the greater power of the newer telescopes. The telescope has also enabled many more comets to be discovered than could possibly be seen with the naked eye in olden times.

ROMANCE of BRITISH HISTORY

THE DRAMATIC END OF A PRIME MINISTER

Here is the dramatic story of how a Prime Minister of England was assassinated in the House of Commons and how a man living in Cornwall saw the whole incident in a dream, a record which is quite well authenticated

Once and once only in the history of England has a Prime Minister been assassinated in the House of Commons. It was a dramatic end to a career which had been brilliant and rapid.

The Prime Minister in question was Spencer Perceval, a son of the Earl of Egmont, and although he had entered Parliament only in 1796 and first taken office as Solicitor-General in 1801, he became Prime Minister in 1809, an office which he held till his tragic death on May 11th, 1812.

It was a senseless murder by a disgruntled man who cherished the idea that he had been badly treated by the Government. He had no personal grievance against the Prime Minister, and declared after the assassination that had he met another minister he should have shot him instead of Mr. Perceval.

It is a terrible thought that a great or brilliant man can have his life ended in a moment by a madman who either cherishes a false grievance or mistakes his victim for someone else.

On the afternoon of Monday, May 11th, the House of Commons had gone into committee, and Mr Perceval, hearing that some important business had commenced, hurried off from his home in Downing Street to the House and walked rapidly through the Lobby.

The Assassin Fires

A man had been standing for some time in the Lobby near the door through which Members entered the debating chamber. He was a tall figure and was dressed in a snuff coloured suit. Just as the Prime Minister had reached the door into the House this man raised his arm and fired point-blank at Perceval's breast.

The Lobby was crowded with members at the time, and the man had stood there almost unnoticed. But directly the crack of the shot rang out all eyes turned towards the door. A member who was present in the Lobby said that he noticed a small curling wreath of smoke like the breath of a cigar rising above Perceval's head.

"I saw him," said the member, "reel back against the ledge on the inside of the door, and then, making an impulsive rush as it were to reach the entrance of the House on the opposite side, I saw him totter forward not half-way and drop dead between the four pillars in the centre of the space, with a slight trace of blood issuing from his lips."

The assassin made no attempt to get away, and when an officer of the House called out "Where is the rascal that fired?" he said "I am the unfortunate man."

The member for Liverpool, General Gascoigne, thereupon seized him with great force, and the assassin's arm was almost broken. Other Members came up and the man was searched. In a pocket was found another loaded pistol, together with some papers.

At this moment General Gascoigne recognised the assassin, and exclaimed "Good God! It's Bellingham!"

The man was indeed well known to the general, and to many other members of Parliament, and also to ministers. He was a Liverpool broker, who had become bankrupt after a very varied career.

Just as the Prime Minister reached the door the man raised his arm and fired point-blank

Born at St. Neots in Huntingdonshire, the son of a land surveyor who had spent a number of years in a madhouse and died insane, Bellingham was bound apprentice to a jeweller. But not caring for this career, he ran away, obtained an ensign's commission in an East India regiment, and sailed for the East.

The vessel was wrecked on the passage out, and thereupon Bellingham gave up the idea of going to India, and returned to England, where he became a tinplate worker.

Then he married an Irish wife, but trouble seemed to dog his steps. The house in which he lived was burnt to the ground, and soon afterwards he became a bankrupt. He next became an insurance broker, but failed owing to lack of capital. Later he entered a merchant's office in Liverpool, and the firm sent him to Archangel in Russia as a commission agent. He seems to have drawn bills on his firm for £10,000 and then used the money on his own account. He had some wild scheme for making a fortune, which, of course, failed.

In a Russian Prison

Returning to England he was sent to prison, and on his release went again with some Hull merchants to Russia. But misfortune still followed him. There was some dispute about the loss of a vessel in the White Sea, and Lloyd's refused to pay the insurance. Bellingham was arrested by the Russians and the British Ambassador was unable to do anything on his behalf. He was condemned and sent to a Russian prison, where he spent five years of his life.

When he was released he returned to England full of grievances with which he pestered the various ministers and Members of Parliament, including the Prime Minister himself.

He wanted compensation for his treatment in Russia, and on May 10th, 1810, he took a petition to Downing Street, where Mr. Perceval's private secretary told him that the Prime Minister would not give permission for the introduction of the petition to the House. The refusal was made quite courteously.

Sir Samuel Romilly, the famous law reformer, wrote: "Perceval, as was his duty, refused to listen to these applications, but he could hardly have accompanied his refusal with any

harshness, for few men had less harshness in their nature."

Bellingham seems to have made himself a great nuisance. At last, on March 12th, 1812, he made his last effort to get compensation. He forwarded a printed circular setting forth his grievances to the Prime Minister, the other ministers and every member of the House of Commons, enclosing with the circular a copy of a petition to the House and the replies he had received to his applications.

A week after the assassination Bellingham was brought to trial and his counsel tried to prove that he was insane. There seems little doubt that this contention was true. Undoubtedly Bellingham's counsel should have been allowed by the judge to bring witnesses to testify to the prisoner's mental condition. But the court refused, and this can hardly be regarded as anything but a breach of justice.

Short Shrift

The trial was very soon over. Bellingham confessed that he had intended to shoot Lord Granville Leveson-Gower because of that statesman's refusal to support his claims on the Russian Government. "But," he added, "Perceval appeared, and I felt that I must kill someone."

On May 18th, exactly a week after the tragedy, he was executed, refusing obstinately to the last to express any compunction for his crime, though he said he lamented its consequences in the grief caused to Mr. Perceval's widow and children.

Mr. Williams's son came hurriedly into the room and exclaimed, "Father, your dream has come true; Mr. Perceval has been shot in the House of Commons"

But this is not all the story. There is a very remarkable incident in connection with it. Perceval himself seems to have had, a few days before the assassination, strange forebodings that his death was imminent, and he actually handed over his will to Mrs. Perceval because of these feelings.

That, however, was not the only curious matter affecting the Prime Minister's death. A man away in Cornwall some days before dreamed that he saw the assassination take place in the Lobby of the House of Commons. He was John Williams, who lived near Redruth, and he has written an account of his dream. Here it is.

Being desired (he says) to write out the particulars of a dream which I had in the year 1812, before I do so, I think it may be proper for me to say that at that time my attention was fully occupied with affairs of my own, the superintendence of some very extensive mines in Cornwall being entrusted to me. Thus I had no leisure to pay any attention to political matters, and hardly knew at the time who formed the administration of the country. It was therefore scarcely possible that my own interest in the subject should have had any share in suggesting the circumstances which presented themselves to my imagination. It was, in truth, a subject which never occurred to my waking thoughts.

My dream was as follows: About the 2nd or 3rd of May, 1812, I dreamed I was in the lobby of the House of Commons, a place well known to me. A small man dressed in a blue coat and white waistcoat entered, and immediately I saw a person, whom I had observed in the first instance dressed in a snuff-coloured coat and yellow metal buttons, take a pistol from under his coat and present it at the little man above mentioned. The pistol was discharged, and the ball entered under the left breast of the person at whom it was directed. I saw the blood issue from the place where the ball had struck him. His countenance instantly altered, and he fell to the ground.

Upon inquiry who the sufferer might be, I was informed he was the Chancellor of the Exchequer. I further saw the murderer laid hold of by several gentlemen in the room.

Upon waking, I told the particulars to my wife. She treated the matter lightly, and desired me to go to sleep, saying it was only a dream. I soon fell asleep again, and again the dream presented itself with precisely the same circumstances.

After awaking a second time, and stating the matter again to my wife, she only repeated her request that I should compose myself and dismiss the subject from my mind. Upon my falling asleep the third time, the same dream, without any alteration, was repeated, and I awoke, as upon the former occasion, in great agitation.

So much alarmed and impressed was I by the circumstance above narrated that I felt much doubt whether it was not my duty to take a journey to London and communicate upon the subject with the party principally concerned.

Upon this point I consulted some friends whom I met on business at the Godolphin mine on the day following. After having stated to them the particulars of the dream itself, and what were my feelings in relation to it, they dissuaded me from my purpose, saying I might expose myself to contempt or vexation, or be taken up as a fanatic.

Upon this I said no more, but anxiously watched the newspaper every evening as the post arrived. On the evening of 13th May, as far as I can recollect, no account of Mr. Perceval's death was in the newspapers.

A True Dream

But my second son, returning from Truro, came in a hurried manner into the room where I was sitting, and exclaimed: "Father, your dream has come true. Mr. Perceval has been shot in the Lobby of the House of Commons. There is an account come from London to Truro, written after the newspapers were printed."

Some weeks after the assassination, business took Mr. Williams to London, and he naturally went to the Lobby of the House of Commons. He pointed out the spot where Bellingham had stood in his dream, and also the place where Mr. Perceval fell, and these proved to be exactly the right spots. Moreover, he described accurately the positions of other people at the moment of Bellingham's arrest, although he did not know who these men were. He simply described them by their dress.

But still stranger is it that this was not the first time that a member of Perceval's family had had a premonition of coming death. A century and a half earlier the body of Robert Perceval, a youth of nineteen, was found by watchmen in the Strand during the early hours of June 5th, 1667.

He had come to London to study law, and was under the guardianship of his uncle, Sir Robert Southwell, who told some strange circumstances preceding the death of Robert to Robert's nephew, the Earl of Egmont. The earl wrote an account as follows:

Robert (says the Earl) was but twenty when he was murdered in the Strand by villains that, to this day, are not found out, and lies buried at Lincoln's Inn, near one of the pillars underneath the chapel Some circumstances concerning his death are too extraordinary to be passed by, and what I am going to relate I had from two persons whose sincerity I can depend on

A few nights before the murder Robert, who was a student in Lincoln's Inn, was sitting in his chamber reading, and it was late at night, when there appeared to him his own apparition, stalking into his chamber

My uncle was so astonished at the sight that he immediately swooned away; but, recovering, he saw the spectre walk out again and vanish downstairs. When he was recovered of his fright he undressed himself and went to bed, but in extraordinary uneasiness, so that he could not sleep, but rose early, and, putting on his clothes, went to his uncle and guardian, Sir Robert Southwell, who lived in Spring Garden

It was so early that Sir Robert was not yet stirring, but nevertheless he went into his room and waked him. It was a freedom he was not used to take, and Sir Robert was surprised, but, asking him what made him there so early, my uncle, still in consternation, replied he had that night seen his ghost, and told him all the particulars as I have related them

Advice to be Cautious

Sir Robert at first chid him for reporting an idle dream, the effect of an ill life and guilty conscience (for he loved his pleasure, and followed it too much); but, observing the disorder he was in, and having repeated the story to him, he grew very serious, and desired his nephew would take care of himself, and recollect if he had given occasion to any person to revenge himself on him; for this might be a true presage of what was to befall him.

My uncle after some time left him, and, notwithstanding the impression thus made at first, I suppose he wore it off soon, or else it were impossible he could be so careless of himself the night he was killed. For that evening he was dogged from house to house where he visited by a single man, who followed him at a small distance, who when my uncle went into a house would wait like a footman in the porch till t'other came out; insomuch that once or twice he spoke to him, asking what was his business in following him so close, and the other answered what was that to him, he was about his own business.

Nay, when my uncle told his friends he was dogged, he would not let them send a footman to attend him; and when at eleven o'clock at night he was assaulted by two or three, and wounded slightly as he entered a tavern in the Strand, where some friends of his were, he would take no warning, nor admit any one to see him safe away, though the tavern boy was so urgent with him that he chid him for his impertinence

But, leaving that company, he was a little time after found dead by the watchmen in the Strand, supposed to be killed in a house and laid there afterwards I have the examinations taken by a coroner's inquest now by me, but they could not help to a discovery This my uncle Southwell told me a little time before he died, word for word.

It is said of this unfortunate young gentleman, that when he came into the tavern before mentioned, he called for a glass of brandy, saying he was a little faint; and then, after having wiped his sword, which was stained with blood (as he said) of one of those by whom he was assaulted, and whose business (as he expressed it) he had done; and after having with his handkerchief tied up his leg, which was wounded, as he was going out of the house to return to his own chambers, he stepped back to tell the master of the tavern that he should remember that he had been attacked by persons who bore him an old grudge, and that, if he was murdered, his friends would find it out

Robert Perceval after being attacked and wounded returned to the Tavern and tied up his leg with his handkerchief

His person and conversation were both more agreeable to others than advantageous to himself, for they led him into company which proved his ruin Example and fashion had, as it generally has upon men of his years, too great an influence, which showed itself in most of his actions, and in one particular (in which it was exaggerated by a great courage and high spirit) in a remarkable degree; for he had been engaged in nineteen duels before he was twenty years of age, in all of which he came off with honour, and commonly with advantage.

A stranger's hat with a bunch of ribbons in it was found by his side, from whence it was at first hoped that the murderer might be discovered; but this expectation was found vain For though the King by his proclamation, and the family by all proper inquiries, endeavoured to bring the offenders to justice, no positive or certain proof was ever attained to, and the villainy has as yet escaped at least a publick punishment Some imagined it was done by Beau Fielding, with whom he had a quarrel at a play, others by a near relation to Sir Robert Southwell's wife.

Help for the Family

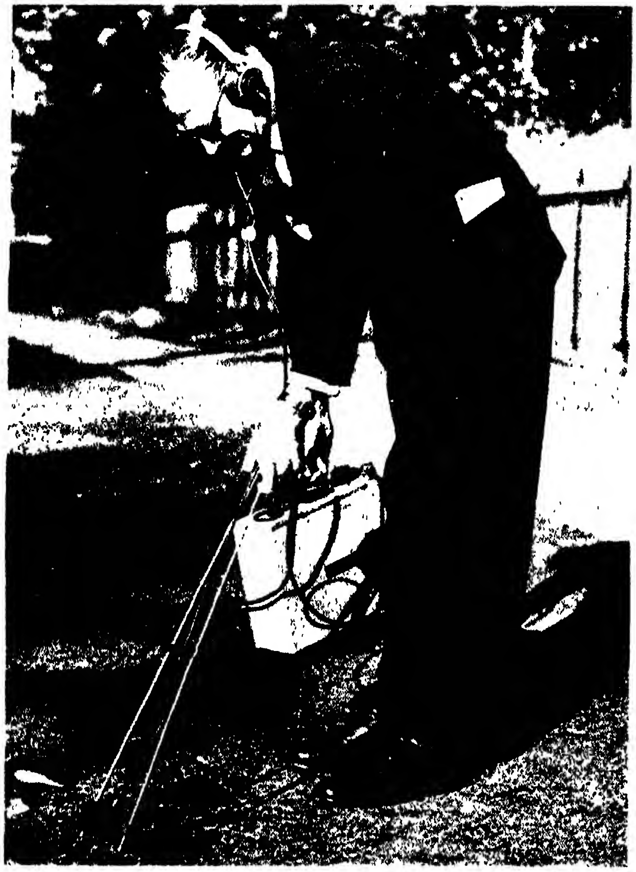
But to return to Spencer Perceval, the Prime Minister A message was delivered to the House from the Prince Regent, afterwards George IV, which said: "The Prince Regent, deeply impressed with the serious loss His Royal Highness and the country have sustained in consequence of the murder of the Right Honourable Spencer Perceval, and being desirous of marking his sense of the public and private virtues of Mr Perceval, and of affording relief and assistance to his numerous and afflicted family, recommends to the House of Commons to enable His Royal Highness, in the name and on the behalf of His Majesty, to make such provision for the widow and family of the Right Honourable Spencer Perceval as to the justice and liberality of Parliament may seem proper "

This was agreed to, and the House made a grant of £60,000 to the Perceval family, £10,000 to the eldest son, and an annuity of £2,000 to Mrs Perceval during her life, which was afterwards to descend to her eldest son

It was decided to raise a public monument in Westminster Abbey to Spencer Perceval's memory, and he would have had a public funeral, but that the family earnestly desired that it should be a private one.

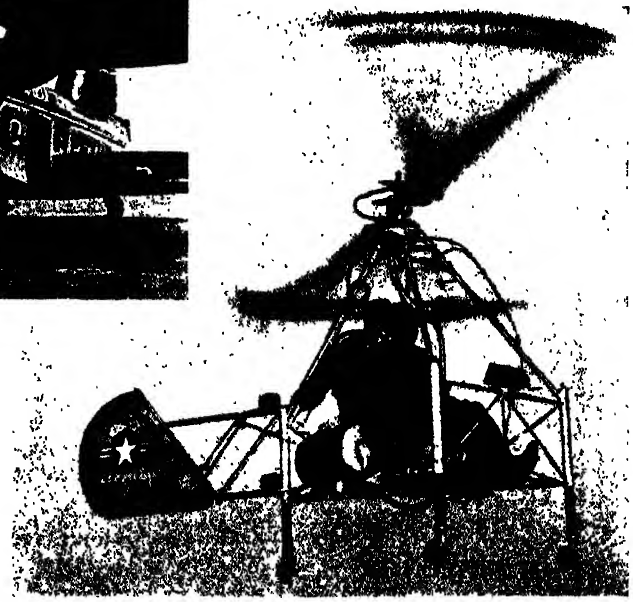
This strange and dramatic death of a Prime Minister was a remarkable affair, and caused a great sensation

MACHINES THAT SAVE TIME AND LABOUR



Man is always inventing machines to save time and labour, and on this page you see four ideas that save a lot of work. Sometimes electricity authorities forget where they have laid cables, and when they want to find them would have to dig up a lot of ground but for the instrument shown on the top left-hand photograph. Every wire carrying an electric current creates a magnetic field, and this can be picked up by a receiver, rather like that of a radio set, as the probe held in the operator's left hand moves across the ground. The influence of the magnetic field actuates a small buzzer, the note of which is heard in the operator's earphones ; the louder the note, the closer the probe is to the buried cable. The right-hand photograph shows a small tractor, with two wheels mounted one behind the other, which is used on railways for shunting wagons

Above you see a Bristol Freighter aircraft, specially designed for the easy loading of heavy cargoes. The nose of the aircraft swings open so that the load can be pushed straight into the fuselage. This idea makes loading much easier than when cargo has to be loaded through doors in the side of the fuselage. On the right is a photograph of a small jet-propelled helicopter which was designed for moving engineers quickly from place to place when inspecting the progress of dams and other large constructional works. It weighs 3 cwt. and can carry a weight of 6 cwt. Known as an "aerial motor cycle," it is also used for laying telephone wires across rough country.



THE VERY GREAT IMPORTANCE OF WATER

It is a good job that there is so much water on the Earth, for every living creature needs large quantities of water and cannot exist without it. That is one of the reasons why a world without water, like the Moon, is a world without life. In these pages we read why living creatures must have a constant supply of water

It is quite impossible for human beings, or indeed for any of the higher animals, to live for long without water. We sometimes read of men at shows fasting for forty days in order to earn money, and it is perfectly true that men have gone without food for this period, and even longer, and still remained alive.

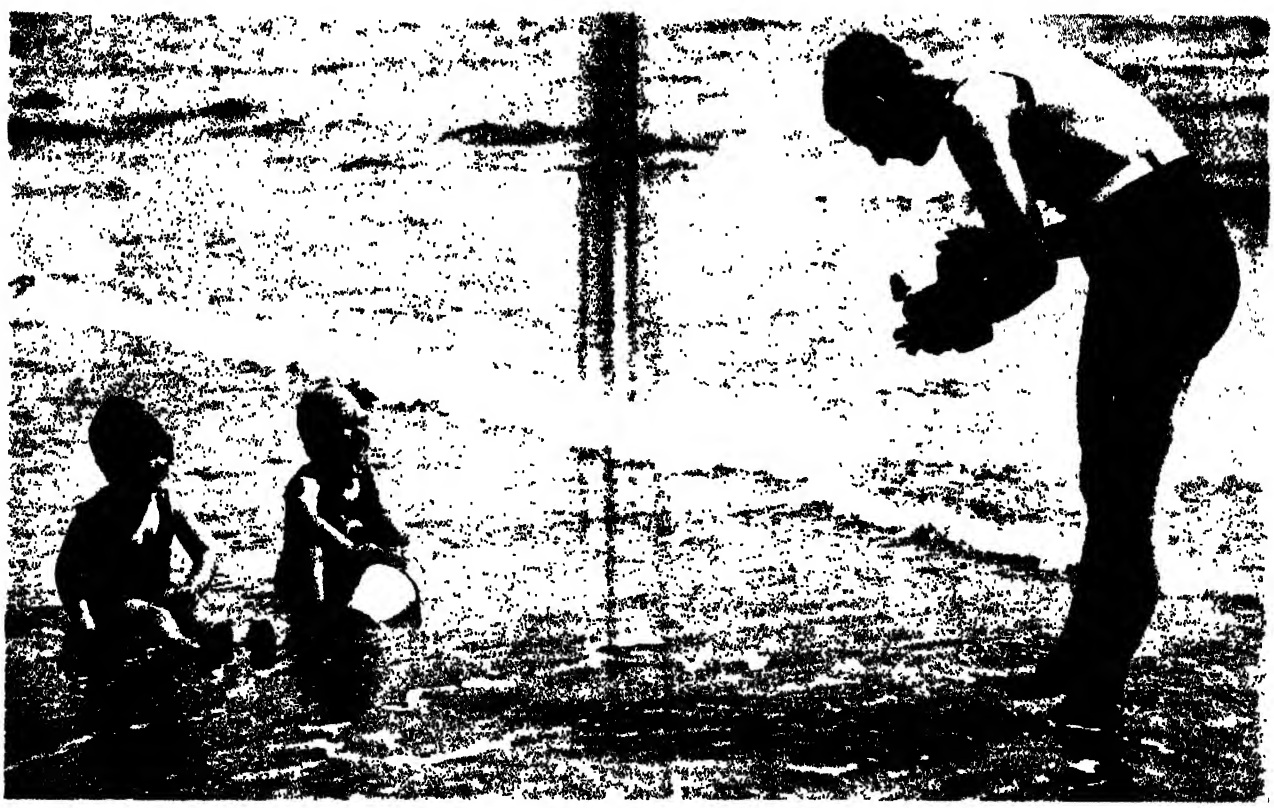
But if we read the accounts of their fasting we shall always find that they are well supplied with water. It would be quite impossible for a human being to live for forty days, or even for a week, without water. Two-thirds of the weight of our body consist of water, and even three-quarters of our skin, hair and muscles are made up of water. Half the weight of bone in our bodies and one fourth of the fat consist of water. A constant supply of water is therefore absolutely necessary to maintain the body.

But apart from this the water is needed for another purpose. We are able to live only when our bodies are within a very narrow range of temperature, and as we move about from cold climates and places to warm places, as the season changes from hot summer to cold winter, a very delicate mechanism is needed to adapt our bodies to the changing conditions and prevent them from getting too hot or too cold.

It is by means of water that this is done. In hot weather, or in the engine room of a ship or factory, we should get far too hot for health, or even for life, were it not for the stream of water which is constantly passing through our bodies. In hot weather we drink a great deal more than we do in winter. Our bodies cry out for water, and though we may take it in the form of tea or coffee or lemonade it is the water and not the flavouring that our bodies demand.

The water passes into our body, and then, by means of millions of tiny glands known as sweat glands, it passes to the outside of our skins as moisture, and is evaporated by the warm air. This evaporation cools our skins and our bodies, and prevents them from becoming too hot for health and life. Even hot tea in summer will keep us cool, for it causes us to perspire, and when the perspiration evaporates from our skin at least fifty times as much heat is carried away from our bodies as the hot tea put into them.

Most people drink far too little water. Our bodies manufacture, from the hydrogen in the food we eat and the oxygen of the air we breathe, about a pound of water a day, but this is nothing like enough for our needs. We really have to live in a running stream of water. More than half the food our bodies require consists of water. In



One of the marvels of the human body is that although there are in almost all parts of it minute tubes through which water is constantly passing from the body into the air, yet water cannot pass the other way through these tiny tubes into the body. If it were not for this one-way traffic of the sweat glands, we should be unable to bathe or take a bath. The children shown in the photograph can sit in the sea without a single particle of water entering through one of the two million or more sweat glands scattered about their bodies

other words, 58½ parts out of every 100 of the substances we take to keep us alive must be water.

No animal can live without water, for all animal tissue is largely composed of it, and it has been very truly said that "to be dried is to die."

Of course, we perspire a great deal more in hot weather, or when we are taking violent exercise than we do in winter, or when we are sitting quietly. But even on an ordinary day, when the weather is not exceptionally hot, and when we are not exercising unduly, our skin discharges about 25 ounces of sweat, and more than 90 per cent. of the sweat consists of water.

We must remember we are not perspiring only when we see beads of moisture on our skins. We are always perspiring, but when the sweat glands get unusually busy, as when we are very hot, or have been taking violent exercise, then a great deal of moisture is given off by the skin.

The sweat glands or pores consist of long tubes which open at one end by a valve like mouth. They are found in every part of the skin, and are nearly always at work. They are particularly numerous and large in the palms of the hands, the soles of the feet, the forehead and the sides of the nose, but there are very few on the back. Each one of us has about two-and-a-half millions of these sweat glands, and they are all surrounded by a network of capillaries, or tiny blood vessels. In a full grown man the sweat glands put end to end would reach a total length of ten miles.

It is very wonderful to remember that our skins, although supplied so richly with these sweat glands that we can be giving off moisture all the time, are nevertheless waterproof in the opposite direction. No matter how much we immerse our bodies in water the liquid cannot enter through the skin. This is owing to the valves with which the sweat glands are fitted.

It is a very good thing that we are so wonderfully made, otherwise we should not be able to go swimming, nor would it be safe to have a bath or even wash our hands!

It is a very serious thing to have the outlets of the sweat glands sealed up, as when a person is tarred all over the skin. The tar needs to be removed promptly. Once a small child riding in a procession as Cupid was gilded all over the body and it died because the gilt paint had filled up the pores of the skin, and the sweat glands were then unable to carry on their work.

THE COCKATOO & MACAW & THEIR POWERFUL BEAKS

Birds of the parrot tribe like the cockatoo and macaw, shown in this photograph, have very powerful beaks that in appearance are somewhat like those of the carnivorous birds of prey. The members of the parrot family, however, are vegetarians, and their powerful beaks are needed for cracking nuts and other seed cases which provide their food in their natural haunts. It is a great mistake to give birds of this family, when they are in captivity, scraps of meat, gravy, sweets and suchlike food, as it makes them unhealthy and often leads to the deplorable habit of feather-eating. Nuts, seeds and fruit are the foods on which they live in the wild state. With its formidable beak the cockatoo, a specimen of which is shown on the left, can saw and hammer and unfasten screws, and even open the links of metal chains. The macaws, one of which is shown on the right, also have very powerful bills, and can give a nasty nip to a finger. They seem particularly fond of nipping boys and girls, so that it is best to keep at beak's length. There are many hundreds of species in the parrot family, some large and some quite small

A CREATURE WHICH GROWS ITS OWN HOME

The story of the development of the tortoise is a very strange one. Here is an animal which moves about very slowly and carries on its back a house into which it can retire when danger threatens

In far-back times the tortoise did not have a shell or carapace on its back, but it started to develop an armour-plated skin made up of bony nodules covered with a sheath of horn, and as this, in the course of time, increased in weight and size, it hindered the movements of the animal's backbone

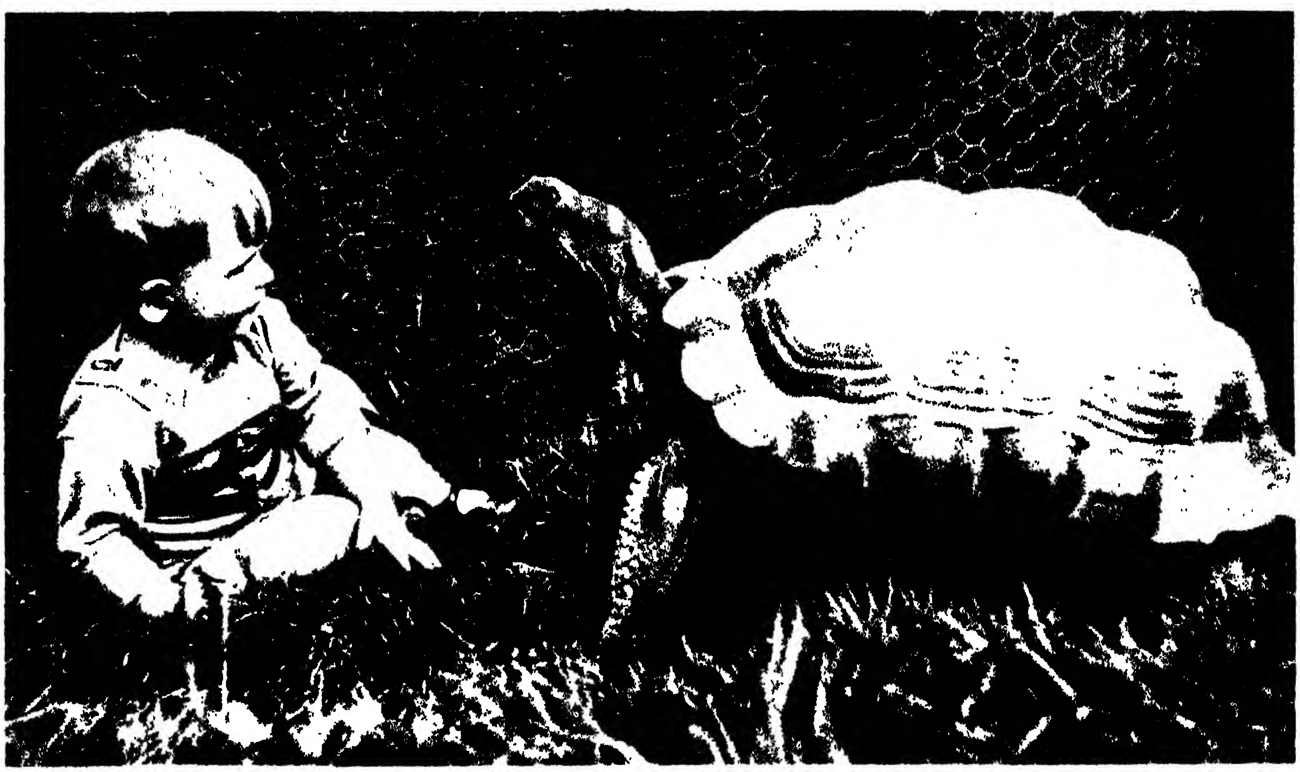
The result was that the muscles of the back, having less and less work to do, dwindled away, and the back shell gradually became lowered on to the ribs and spine till at last shell and ribs became welded together, forming the shell of the tortoise as we know it to-day.

The bony plates have become beautifully linked with the ribs, but down the middle of the shell, if we examine a tortoise, we can still see the tops of the spines of the backbone The tortoise having developed this heavy armour for protection, something had to be sacrificed, and it was speed that went The tortoise now crawls about very slowly and deliberately, carrying the heavy carapace, which is a combined house and skeleton, with it

A tortoise in an English garden making its first meal of lettuce leaves after waking from its long winter sleep

There are small tortoises like the Greek tortoise of Mediterranean countries, which are often kept in English gardens, and there are giants like those of the Galapagos Islands, which sometimes weigh over 600 pounds and are more than four feet long These live for several centuries

The European tortoise is an interesting animal to keep as a pet People with no knowledge of natural history often buy specimens to destroy black beetles or other insects, but, of course, the tortoise is a strict vegetarian It loves water, and in warm weather if placed under a running tap will put out its neck in different directions to get well bathed. It hibernates during the winter, burying itself just under the ground, often in a flower bed, and appears again next year when the weather begins to get warm. It is very hungry after its sleep



A giant tortoise in an English zoo which is big enough and strong enough for a boy or girl to ride on its back. In its native haunts this animal, which lives for several centuries, grows much bigger than the specimen in the picture, often reaching four feet

A GIANT TORTOISE AND ITS LONG NECK

Very few of these giant tortoises are now left in the Galapagos Islands, where they once abounded. They measure as much as four feet in length and weigh sometimes over five and a half hundredweights. They used to be killed for their meat, each tortoise yielding two hundred pounds. Although in the ordinary way when withdrawn into its shell the tortoise appears to have very little neck, it can if necessary extend its head far beyond its shell, when it will be seen to have a very long neck indeed. If, for instance, the tortoise wants a drink it will stretch its neck to the full length in order to reach the water

THE PLANT WIZARD AND HIS GREAT WORK

EVER since early man, or perhaps it was woman, found that the fruits of certain wild plants were pleasant to taste and useful for satisfying hunger, attempts have been made to improve these, so that larger and more luscious fruits might be obtained.

In the last thirty or forty years more success has been achieved in this way than in all the centuries that went before, for instead of letting Nature do her own work and merely selecting the most suitable plants from what she produced, man has now brought science to his aid and helps and hurries up Nature, so that in a few years he has produced thousands of varieties of new fruits, larger and more luscious, and growing on their trees or bushes in greater abundance, than had even been dreamed of by our grandparents.

What is true of fruits has been equally true of flowers, and we have only to visit a large garden or look through a nurseryman's catalogue to see the extraordinary developments that have been brought about. There are thousands of kinds of roses of various shapes and colours, and hundreds of varieties of sweet peas, lilies and other lovely plants, with an astonishing range of form and colour.

Of all the men who have worked for the world in this way none has achieved such amazing results as Luther Burbank, the Plant Wizard. We read in another part of this book of how he produced the spineless cactus to provide cattle food in the deserts of America, but that was only one of his many thousands of triumphs.

A Famous Potato

As a youth he was always experimenting in plant culture, and his first success was with the potato. The potato plant does not usually produce seed, but young Burbank noticed one day a plant with a cluster of 23 seeds. He collected the seeds and in due course planted them. To his great surprise no two seeds produced the same kind of potato. One, however, yielded tubers of a remarkable size and whiteness, so he saved these and planted them the next year. They reproduced their fine qualities, and he realised that he had created a new potato, which ever since has been known as the Burbank potato, of which it is estimated that £5,000,000 worth have been raised in the United States alone.

All Burbank received for his achievement, however, was £30; but this enabled him to move from his home in Massachusetts across America to California, when he decided to carry on his experiments under the very favourable weather conditions found there.

From that time until his death, Burbank spent his whole life in carrying out experiments in plant-breeding. He produced many millions of plants, and at one time had growing in his grounds as many as 300,000 distinct varieties of plum, 60,000 peach and nectarine trees, 6,000 almonds, 5,000 chestnuts, 5,000 walnuts, 3,000 apples, 2,000 pears, 2,000 cherries, and 1,000 grape vines, besides tens of thousands of other plants. In one season he made over 100,000 grafts, obtaining from them material for ten million fresh grafts.

A Man Who Loved His Work

Burbank loved his work, and he had an uncanny facility in picking out from the hundreds of thousands of plants growing at one time those which presented slight differences worth consideration. His sense of sight was remarkably developed, and experts who tested his eyes declared that he was able to detect differences and variations in colour not noticeable to ordinary people.

His senses of smell and taste also were extraordinarily acute. He could go past thousands of seedlings at an ordinary walking pace and single out or mark one here or there so that at the end of the walk he would have passed in review 20,000 or more plants and selected from them 50 or 60 for further experiment.

Realising that chestnuts were a nuisance to gather because they grew on high trees, he set about producing a dwarf chestnut tree no higher than a gooseberry bush, from which the nuts could be gathered quite easily, without steps or ladders. Then he crossed trees producing giant chestnuts in Japan with American chestnut trees, and improved both the size and flavour of the fruit. He also speeded up the date of bearing, so that the dwarf trees began to have nuts only six months after being planted.

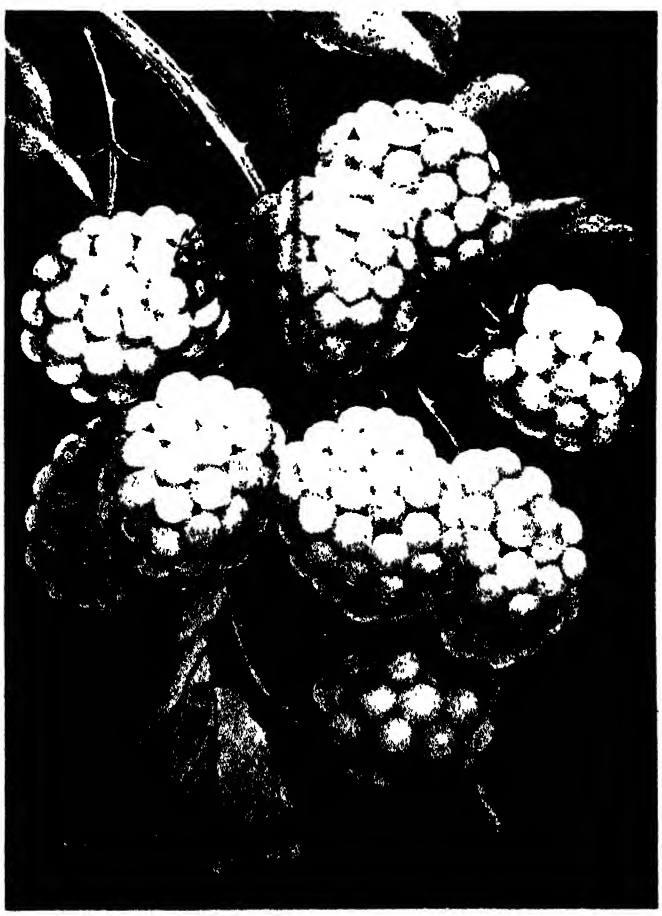
He also carried out some remarkable experiments with walnuts. The hard shells were a nuisance, so Burbank decided to produce walnut trees which should yield nuts whose shells should be so thin that they could be torn off like paper with the fingers, and thus nutcrackers would be abolished.

He succeeded, improving the fruit at the same time. But in this case he overreached himself, for the birds, finding that the nuts could be got at so easily, soon finished up the fruit, and Burbank then had to thicken and harden up the shells of his new walnuts in order to protect them from the birds.

Two Fruits in One

Another wonder that he performed was to produce a plant that would bear peaches with almond nuts inside instead of ordinary stones, two fruits thus actually growing in one. He took the plum and the apricot and combined them so as to create an entirely new orchard fruit which he named the plumcot. This had the qualities of both its ancestors. He crossed the raspberry and blackberry and produced another new fruit, the loganberry, which now grows not only in America but in Great Britain, and produces an abundance of berries.

Less known is his sunberry, a cross between two species of nightshade, one a native of Africa and the other of America. Neither produces an edible fruit, but the hybrid that Burbank created bears a delicious fruit. It took the Plant Wizard 25 years to achieve this result. Effort after effort failed, and then at last he grew a plant which bore a single berry.



White blackberries produced by Luther Burbank, the Plant Wizard

He watched over the precious fruit very carefully until it had ripened, then jealously guarded the seeds and finally planted them, and produced what he had been seeking for

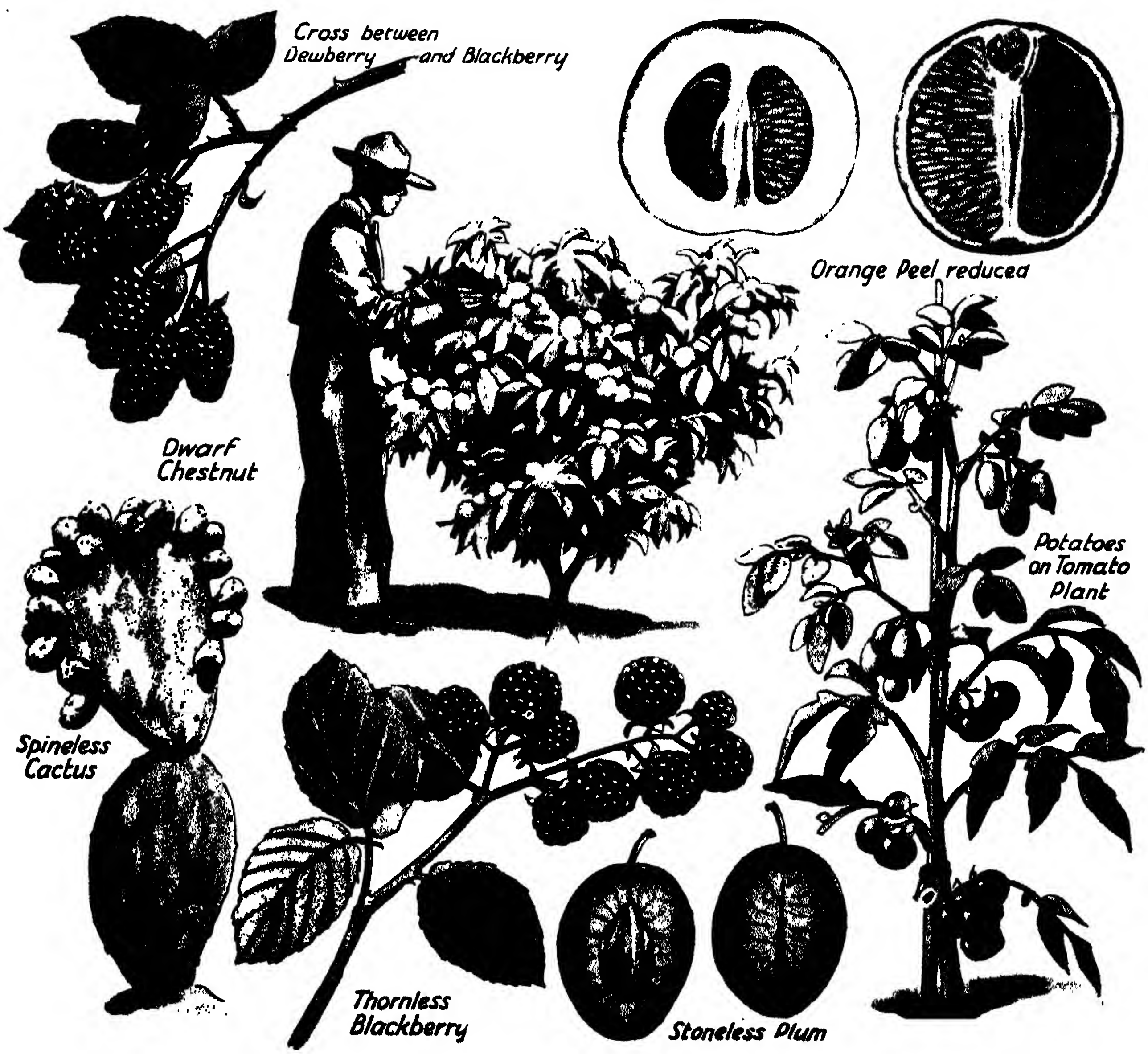
One of his most dramatic productions was a plant that produced potatoes underground and tomatoes above ground He obtained this by grafting a potato plant on to the roots of a tomato vine. He also grew tomatoes and potatoes on the same plant above ground

But all his efforts were not directed towards producing absolutely new plants. In fact, Burbank was never anxious to perform mere horticultural tricks, and he rather disliked the name of Plant Wizard

Perhaps most of his efforts were in the direction of improving existing fruits and flowers and increasing the number of varieties. He performed wonders with the plum, producing in a few years more than sixty new varieties, embodying every possible good quality that could be desired. Some had an exceptional percentage of sugar, others ripened a month or two before usual, some had a very thin skin, others a very red flesh, and one of his greatest marvels was to grow a variety of plum that had no stone inside. To do this he crossed a small European plum, not much larger than a cranberry, which had a very small stone, with certain rich American varieties, and at last produced a very large and luscious plum that could be bitten through like a strawberry. Another achievement was a fine large, white blackberry.

Some of his results were produced by putting the pollen of one plant into another, and some by merely selecting again and again plants which had the qualities he desired. He grafted the selected seedlings on to healthy plants instead of leaving them to bear on their own roots, and in this way got his results much more rapidly.

Sometimes a thousand different varieties of fruit might be seen growing on a single tree in Burbank's plantations. One secret of his success was that he had no hesitation in ruthlessly destroying hundreds of thousands of unnecessary plants



Here are some of the creations of Luther Burbank, the plant wizard of America. By crossing the dewberry and blackberry he produced a new fruit. He also produced a cactus without spines, a blackberry without thorns, and a plum without a stone. In the picture the stoneless plum is shown by the side of a plum with a stone in it. Burbank also grew aerial potatoes on a tomato plant, and produced chestnut and walnut trees no higher than gooseberry bushes, so that their nuts could be gathered easily. He also reduced the thickness of the peel of oranges

MARVELS of CHEMISTRY & PHYSICS

SOUND WAVES THAT WE CAN SEE

The wonders of science never cease and in the achievement of many of these photography plays a large part. Who would ever have thought that the waves in the air set up by sounds would be photographed so as to be seen by our eyes, yet, as we read here, this wonder has been actually accomplished

We all like to stand on the beach or look over the side of a boat and watch the waves move up and down on the water and travel along. But although we know that sound is the result of waves in the atmosphere striking our ear-drums, we do not usually think of these waves as being visible Yet there are times when sound waves in the atmosphere can be seen.

Early in the present century an American scientist was standing on Vesuvius during an eruption Every few seconds there was an explosion and lava and rocky fragments were thrown out of the crater As the professor watched the smoke and dust rise from the volcano he saw a thin ring of light move upwards rapidly from the crater and suddenly disappear. He continued to watch, and at each explosion the same phenomenon was seen A luminous ring shot out of the volcano disappearing immediately These rings moved up far more quickly than the solid matter

A few years later the same scientist saw the rings of light during an eruption of Etna He described them, and explained that the flashing arcs, as he termed them, were really visible sound waves.

The same kind of thing was witnessed during the Great War When the big guns were fired, curved bands of light were often seen to sweep across the sky. They looked very much like the ripples which we see when we throw a pebble into a pond. These also were visible sound waves.

Attempts were made to photograph both the volcanic sound waves and those from guns, but without success Sound waves have, however, been photographed and show up clearly in the case of a rifle bullet flying through the air. A photograph was taken with an exposure of one-millionth of a second, and the light rays passing through a segment of the air which had been compressed by the flying bullet, were distinctly recorded in the train of the bullet

The reason for the visibility of sound waves in the circumstances mentioned is that air bends or refracts light rays according to its density. The light passing through the condensed air which is rapidly expanding to resume its old volume, bends the rays of light so markedly that they are visible to the eye or the camera

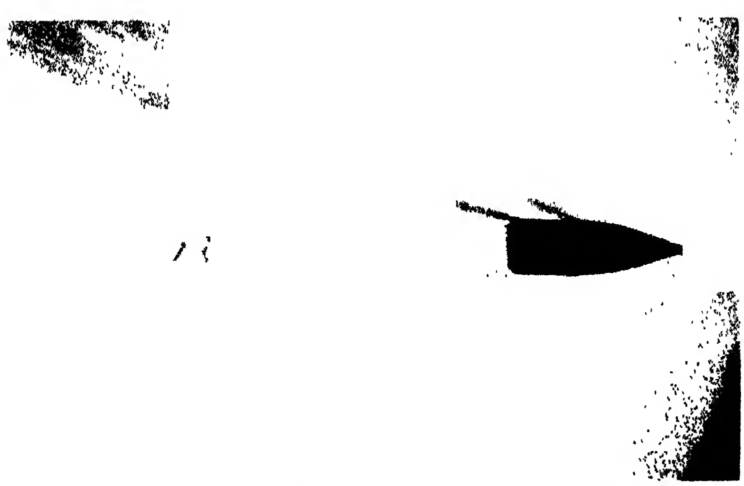
When a silencer is used in firing the bullet from the rifle and a photograph is taken, no sound waves are then visible on the plate, for the simple reason that the sound being reduced there are no waves to make their appearance on the sensitized film

The photographing of sound waves in the manner described is of great interest as a scientific triumph, but it is of more than theoretical interest, for by study of these photographs scientists hope to be able to deal with the loud noise made by a moving aeroplane and to introduce methods or machinery that shall make the aircraft practically silent

The noise of the aeroplane, it has been discovered, comes from three different sources One is the popping of the exhaust, and this can be abolished by a silencer similar to that used with a gun

Then there is the churning of the air by the propeller, which is responsible for about a third of the noise. This can be lessened by using gears, for it is a fact that after a certain point has been reached the aeroplane's speed is not increased by increasing the number of the propeller's revolutions per minute.

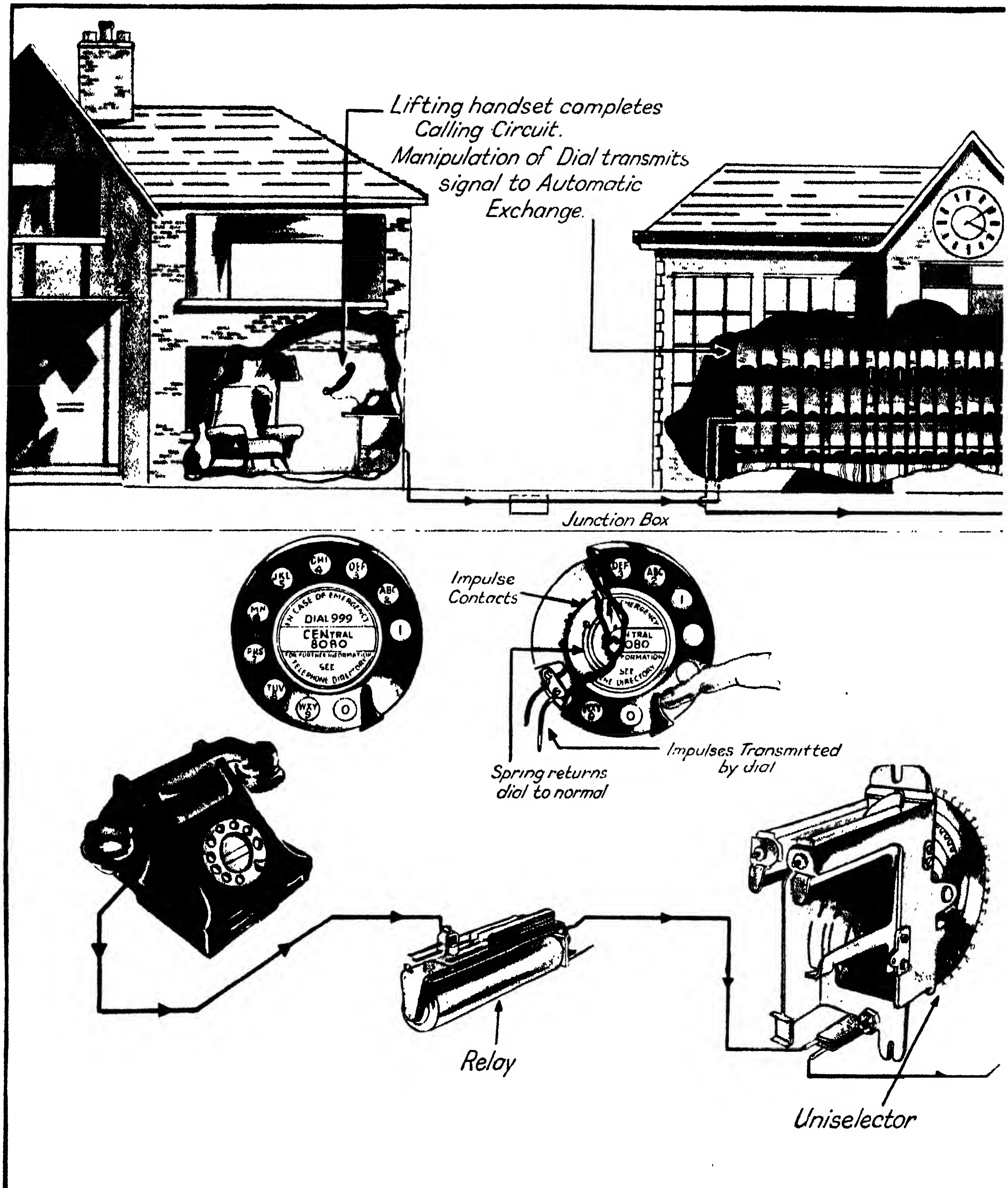
Finally, there is the noise known as "flutter," which is similar to the sound made by a flag in the breeze. The blades of the propeller create a hurricane and the aeroplane as it moves through this is set fluttering in all its parts, and this makes quite a large proportion of the total noise caused by a moving aeroplane. Devices to silence the flutter sounds are being thought out and these instantaneous photographs of sound waves are contributing a good deal of help in the work.



A photograph of a bullet just after it has left the muzzle of the rifle, showing the sound-waves which it causes as it whirls through the air. The photograph was given an exposure of only one-millionth of a second

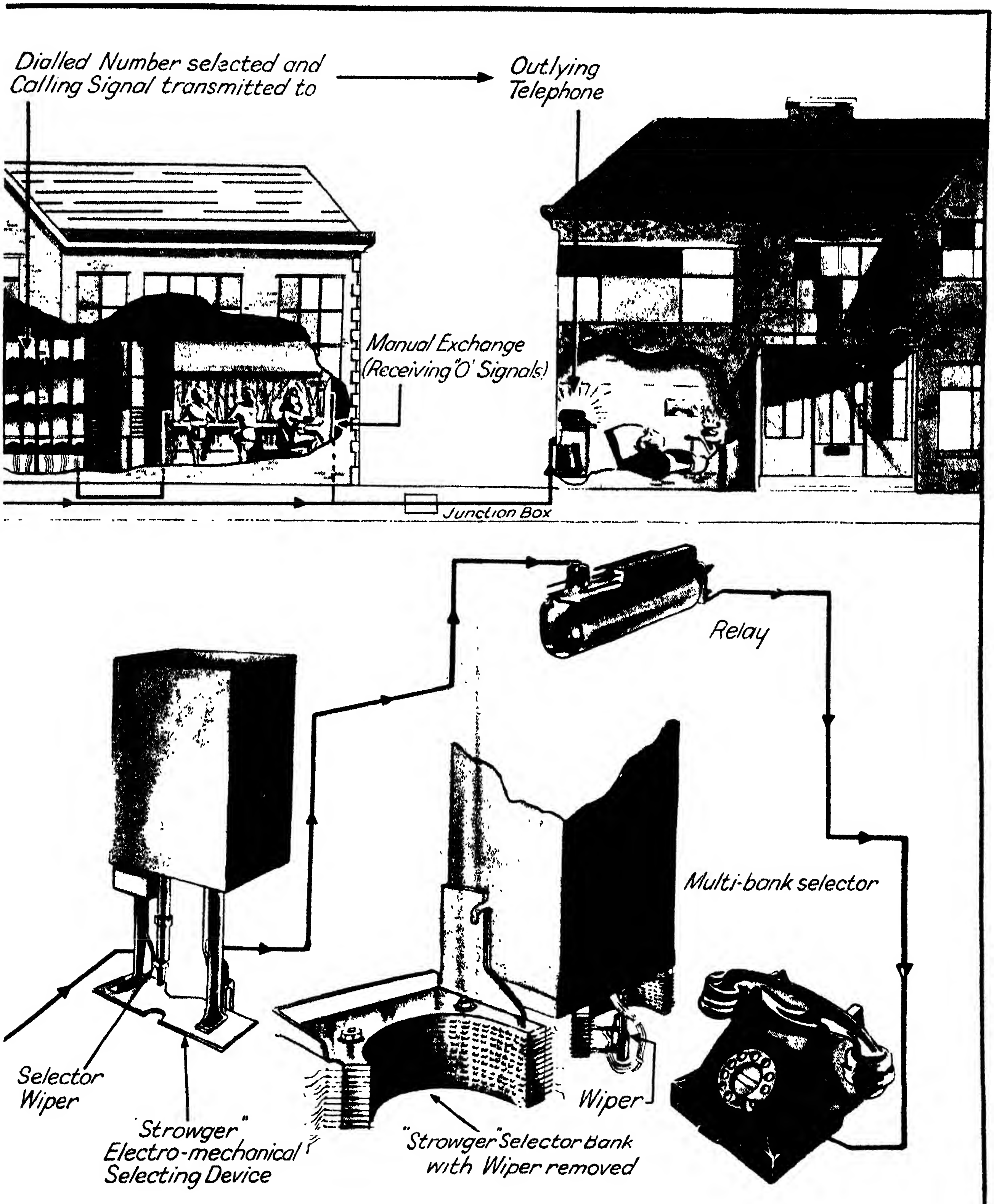
An instantaneous photograph of a bullet just after it has left the rifle's muzzle, when fired through a silencer. It will be noticed that the sound-waves seen in the upper photograph are entirely absent here

HOW THE AUTOMATIC TELEPHONE SELECTS



When you lift the microphone-receiver of an automatic telephone an electrical impulse is generated from batteries at the local exchange and operates a device called a selector which connects your telephone to a disengaged line. If you wish to ring, say, THOrnton 4157, you then dial the first three letters of the Thornton exchange. Behind the dial of your telephone is a row of electrical contacts, one for each finger hole on the dial. Turning the dial from T to the stop at the bottom of the dial causes the contact behind T to close and an electrical impulse is sent out through a switch which is actuated only by the T contact. When the exchange initials THO have been dialled, the impulses operate an instrument at your local exchange called a uniselector, and the uniselector then switches your line from your local exchange to the Thornton exchange. Your telephone is now directly connected to the Thornton exchange. The next step is to connect your telephone to that of Thornton 4157, who is one of perhaps 10,000 connected to the Thornton exchange. So you dial 4157. When you turn the dial from 1 to the stop on the dial rim, an impulse is transmitted along the line connecting you to the

ONE SUBSCRIBER FROM A MILLION OTHERS

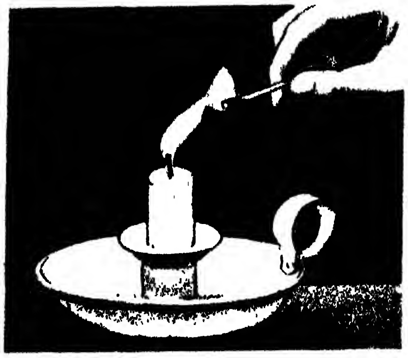


Thornton exchange, and this impulse sets in motion a contact arm, called a wiper, which moves across banks of stationary contacts called a selector. There are 100 contacts on the selector arranged in banks of ten. When you dial 4, number 4 contact is energised and attracts the contact arm to it, so completing an electric circuit ; as this process is repeated for 1, 5, and 7, circuits behind the contacts are closed and generate an impulse which is transmitted along the line connecting 4157 with the Thornton exchange and so rings the bell on telephone 4157. When 4157 lifts the receiver, he has, in effect, a direct telephone line to your telephone, along which both of you can speak. If he is using his telephone when you ring him, or if he does not lift his microphone receiver, the connections made by the wiper on the selector are short-circuited, and operate a buzzer which you hear as the engaged signal.

SIMPLE EXPERIMENTS IN THE SCIENCE OF COMBUSTION

On this page are described a number of simple experiments illustrating facts in the science of combustion.

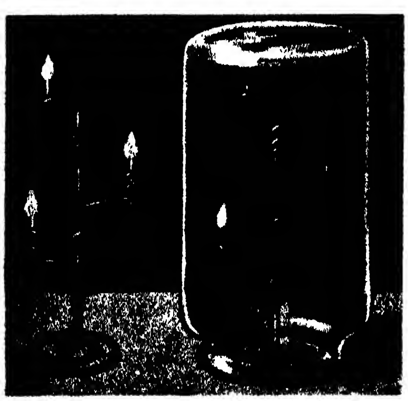
First of all let us take a candle and light it. When it has burnt well for a minute or two blow out the flame and hold a lighted match a short distance from it. The wick will at once relight.



Relighting a candle at a distance

The explanation is that the hot vapour given off by the candle comes into contact with the flame of the match which travels across to the wick, relighting it. If, however, we wait till the liquid fat round the wick is cold, the wick cannot be relighted in this way.

Take a strip of stiff wire about a foot long, and curl round the bottom, to make a stand. Now take three short lengths of wire and bend round the upright at different points. Fasten a wax vesta to each and light them, then invert over the whole a large glass jar. We shall notice that the top flame will go out first, then the second, and finally the bottom one. As the oxygen inside the jar necessary to support



Wax Vestas put out one after the other

combustion is used up the flames go out one after the other, the bottom one being the last because that uses up the last of the oxygen.

Here is another experiment in the extinguishing of a flame. We buy at the chemist a Seidlitz powder and mix the powders out of the blue and white papers in a dry bottle with a wide mouth. We pour some water on the mixture, when there is a great bubbling. After a few minutes we light a match and plunge into the bottle. The light is extinguished. We relight it again and hold it at the mouth of the bottle. Again the flame is extinguished. The reason is that carbon-dioxide gas is being formed in the jar, and this is not a supporter of combustion and so the flame goes out.

Here is an interesting experiment in which we use methylated spirit. We put a tablespoonful into an enamel saucepan, and then take a piece of wire gauze and rest it on top of a cup. We light the methylated spirit and while

A match extinguished by a Seidlitz powder

it is flaming pour the burning spirit through the gauze into the cup. We shall find that though the spirit goes into the cup the flame does not. On

Burning methylated spirit passes through gauze without the flame

the principle of the miner's safety lamp the wire of the gauze absorbs so much heat from the flame that the spirit as it passes through ceases to burn. This experiment is best performed in the open air on a calm day.

Take a small ball of cotton-wool and fasten it to the end of a wire. Saturate it with methylated spirit and light it. Bring down upon the top of the flame a piece of thin glass or mica. As we look through the glass we shall see a hollow ring of flame, and if we blow out the flame the cotton-wool will be charred only in the form of a ring. Inside will be a clean patch. It is clear from this that the flame is hollow.

Another interesting experiment in extinguishing a flame can be carried out with the aid of a bottle of soda water. We take a piece of paper and fold it into a sort of hood which we place over the mouth of a tumbler, leaving an opening on one side. Then, removing the cork from the soda water bottle and allowing no liquid to get

Viewing the hollow flame through a glass

into the tumbler, we hold the mouth under the paper hood. After a minute or two, we remove the bottle and then light a taper and plunge it into the tumbler. It goes out. Although we have seen nothing coming from the bottle, carbon-dioxide gas has been emerging, and this, being heavier than air, sinks into the tumbler. The gas does not support combustion, and so the flame goes out.

Another interesting experiment in combustion is to get a small piece of magnesium wire or ribbon and, holding it in a pair of pliers, place it in the flame of a gas-ring which is really a Bunsen burner and is very hot. In a moment the wire or ribbon will begin

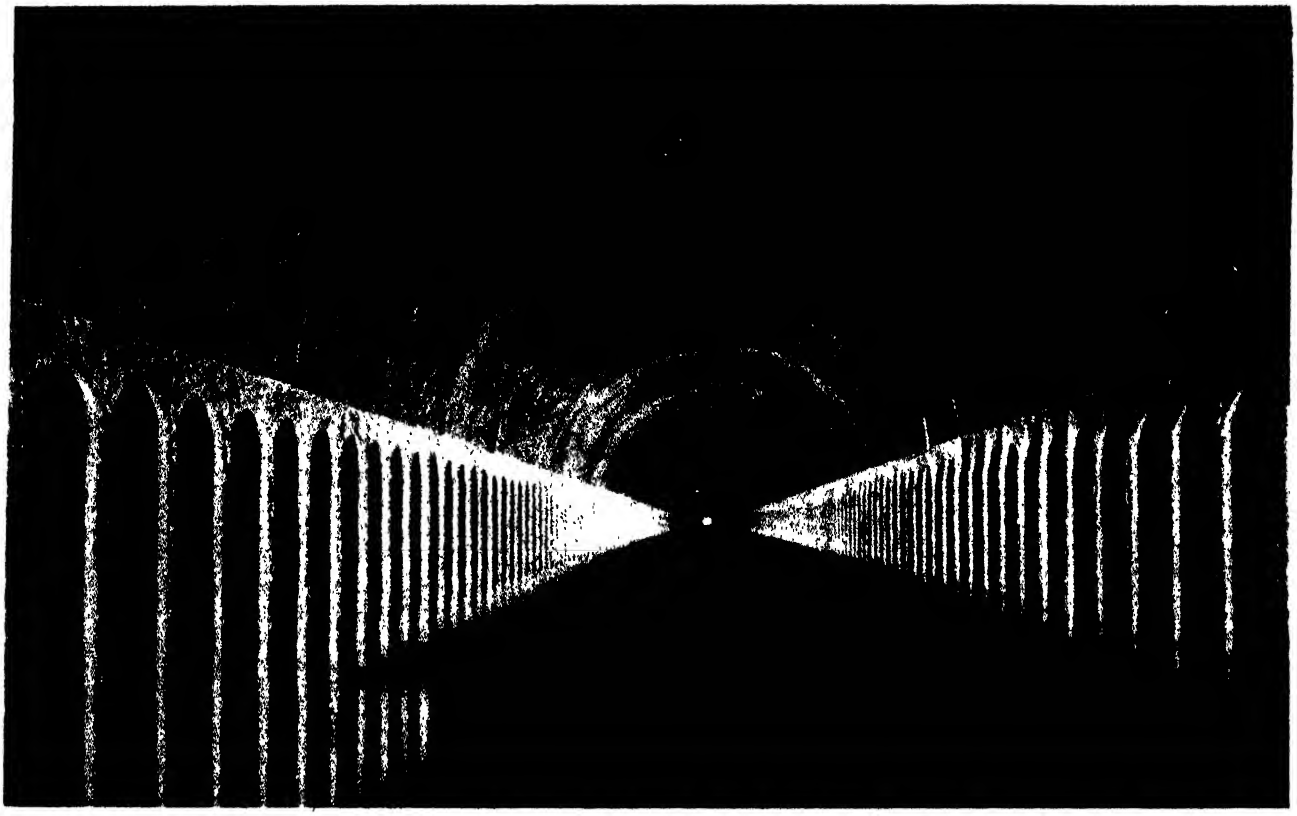
Carbon-dioxide puts out a taper

to burn with a very brilliant light, producing a white substance. This is known as magnesium oxide or magnesia. The magnesium when burning combined with oxygen from the air, just as iron when subjected to damp absorbs oxygen and forms iron oxide or as we generally call it rust. Magnesium wire can be bought at a chemist's or photographic shop.

WHY THE COWL HELPS THE SMOKY CHIMNEY

Many chimneys smoke when the wind is in a certain direction, that is the smoke instead of escaping out of the top of the chimney-pot blows down into the room. Why is this? Well, the reason is that when the wind is in this particular direction it is deflected down by some tall object, such as a tree or an adjacent roof, so that it blows directly down the chimney, as shown in the first picture. Generally the putting of a cowl on the chimney-pot remedies the defect. There are various forms of cowl as shown on the right. One has a wing that causes it to blow round away from the wind. Another revolves preventing the wind blowing directly down the chimney-pot, and another form has slanting rings one above another to deflect the wind outward instead of down the chimney

THE DAYLIGHT AT THE END OF THE TUNNEL



It is difficult to judge distance unless we can see between ourselves and the point we are looking at a number of familiar objects whose sizes we know more or less correctly. If, for example, we are looking at a house several fields away we can judge the distance by noticing the size that the house appears to us and also the size of the various trees and other objects that lie between us and the house. When such objects are absent and when the point at which we are looking is a light that pierces the darkness it is very difficult indeed to get any idea of distance. We can see this by looking at the photograph above. It represents the Rove Tunnel through which runs the Marseilles-Arles Canal, and the point of light in the centre is really the exit at the end of the tunnel. How far away should we think this exit is? Some might say half a mile and others even a mile or more, but as a matter of fact the exit which we see as a white dot is really four miles from the point at which the photograph was taken. It is a striking example of how our eyes may deceive us

BOILING THE KETTLE WITH HEAT AND COLD

When we put a kettle full of water on the fire or gas-ring, the water, becomes heated and gradually rises in temperature till at length bubbles of vapour begin to mount to the surface. When this happens we say the water has reached boiling point. We call the rising of the bubbles ebullition, which is only another word from the Latin for boiling.

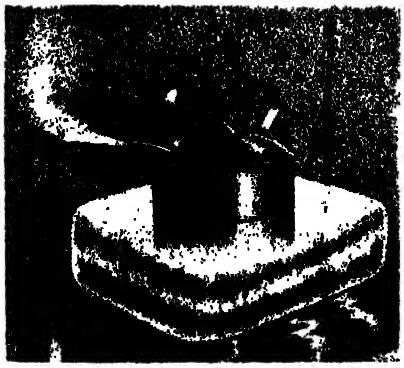
Water boiling at 100 degrees Centigrade

Now the exact point at which the ebullition begins depends upon the nature of the liquid, and it also depends upon the pressure of the atmosphere. For example, at the ordinary pressure of the atmosphere at sea level water boils at 100 degrees Centigrade or 212 degrees Fahrenheit. Acetic acid, under the same conditions, boils at 117·3 degrees C., and mercury at 357 degrees C. On the other hand, alcohol boils at 78·4 degrees C., and ether at 34·0 degrees.

But if the pressure of the atmosphere is different, then the boiling point is different also. At the top of Mont Blanc water boils at 85 degrees C., and it is difficult at this height to cook food in open vessels.

Water can be made to boil at almost any temperature, according to the pressure of the air above it. If the pressure on the surface be increased, then the liquid must be raised above 100 degrees C. before it can boil. In a diving bell 33 feet down water boils at about 119 degrees C.

Men of science carry out an interesting experiment in connection with boiling. They place liquid air in a kettle and then stand the kettle on a block of ice, when it at once begins to boil. The reason is that the ice is intensely hot when compared with the low temperature of the liquid air. It soon raises the liquid air to a temperature of −190 degrees C. or −310 degrees Fahr., which is the boiling point of liquid air.



Liquid air boiling at −190 degrees Centigrade

ROMANCE of BRITISH HISTORY

ENGLAND WHIPS THE BARBARY CORSAIRS

We little realise in these days the perils of the sea a century and a quarter ago when the Barbary Corsairs used to prey on the shipping of all nations in the Mediterranean, stealing the merchandise and carrying off the seamen and passengers to slavery. Here we read how the British took the lead in suppressing these pirates

For centuries the Barbary Corsairs, the pirates of Algiers and other North African ports, were the scourge of Christendom. They preyed upon the commerce of all nations, and incredible as it may seem, even the most powerful of civilised countries paid these robbers of the sea tribute money to allow their merchant vessels to travel from port to port without molestation. The Barbary Corsairs were indeed the gangsters and the racketeers of the Old World.

But despite the tribute money they still preyed upon the shipping, and carried off to their fastnesses not only the rich merchandise of the nations but the people they found on board Christian slaves were a great part of the wealth of Algiers. These unfortunate victims of the brutal and bloodthirsty Corsairs were treated shamefully, flogged and frequently starved and worked to death.

Ransom Societies

The only way they could be saved was by the payment of heavy ransom money, and just as there are to-day societies for the prevention of cruelty to children and to animals, so in those days there were societies for the ransom and rescue of the Christian prisoners of the pirates.

At last the outrages of these African pirates became so persistent and the tribute upon commerce so oppressive that it was felt that something must be done to break their power and pride.

It is an undoubted fact that their pride was as great as their power. They were most insolent in their bearing to powerful Christian countries like England and France, and as we read the story of this scourge of Christendom we are simply amazed that the Powers allowed the Corsairs to go on so long instead of routing out their nests on the North African coast.

Of course, it was the old story; the mutual jealousies of the Christian Powers prevented them from combining and crushing the Corsairs.

To show how bad the menace was it may be mentioned that in two years and a half, up to the end of 1800, no fewer than 23 ships and 200 men sailing under the English flag were captured by the Algerines. These were all engaged in carrying provisions to Nelson's fleet, and yet it was only with difficulty that the English Consul could secure their release from the Dey or ruler of Algiers.

The pirates often swooped down on the coasts of Spain and Italy and kidnapped the inhabitants, carrying them off to slavery.

When a particularly important prisoner was captured by the pirates the Dey would himself purchase the valuable slave and hold him to excessive ransom. Hundreds of thousands of pounds were paid in ransom by the civilised Powers for the release of the Christian slaves captured on the seas

The rulers of Algiers became more and more insolent, and in February, 1806, the English Consul wrote home to his Government: "What I have experienced since my stay here has literally been a summary of all the horrors and indignities that have been offered to the British nation for the last thirty years." The Consul was constantly insulted at his house, his water supply was cut off, and finally guards were sent to turn him out.

Unfortunately the baby began to cry when passing through the gate

Some of the European Consuls were treated worse than this. When the tribute money from Denmark was a little late in arriving, the Danish Consul, who was an admiral, was put in chains and taken through the streets to prison with irons round his leg that weighed upward of fifty pounds

In the morning he was sent out with the other slaves to work in public. Only when all the other Consuls went to the Dey and protested was this unfortunate man released. His wife received such a shock that she died shortly afterwards

When the tribute from the Netherlands did not arrive the Dutch Consul, who had held his post for 23 years, was treated in a similar manner. After being loaded with heavy chains he was sent to work at the arsenal with the other slaves, and threats were held out that if the tribute did not arrive immediately his wife and children would be seized and publicly sold as slaves.

Presents for Pirates

This happened as late as 1808, and the other Consuls were unable to obtain any mitigation. The unfortunate victim died from the effects of his treatment.

Yet the monarchs and governments of the European countries used to send pleasant messages and costly presents to the Dey of Algiers. Sir Arthur Paget, for example, the British Ambassador to Turkey, called at Algiers on his way to Constantinople, to present to the Dey a gold snuff-box set with diamonds from his Government. In return the Dey handed to the Ambassador two Christian slaves.

It is amazing that such acts of courtesy could be interchanged with a gang of ruffians, who heaped indignities upon the Consuls and other officials as well as upon the subjects of the great Powers.

The first nation to take action was the youngest, the newly constituted United States. Its government declared that it would no longer pay tribute, and sent a fleet across the

Atlantic which threatened the pirates, and after some fighting and a blockade wrested a treaty from the Corsair government, by which all money payment was abolished, all captives and properties restored, and immunity given to United States shipping. "Not a dollar for tribute, but millions for warships" was the slogan of the United States. It was a fine lead to an abased Europe.

That was in 1815, and in the following year the English decided that they would stand no more nonsense from these ruffians of Algiers, Tunis and Tripoli. The Ionian Islands, a chain of about forty islands stretching along the west and south coasts of Greece, had become dependencies of Great Britain, but although the inhabitants were now British subjects, the Algerine pirates continued to prey upon them and carry them off to slavery in North Africa.

Early in 1816, therefore, Lord Exmouth was sent on a mission to the Barbary States to insist that the Ionian Islanders should be treated as British subjects. He was further commissioned to bring about a peace between Sardinia and Algiers, and to offer his services to any other Mediterranean Powers that might wish him to treat with the Dey's government on their behalf. The Kingdom of the Two Sicilies availed itself of this offer.

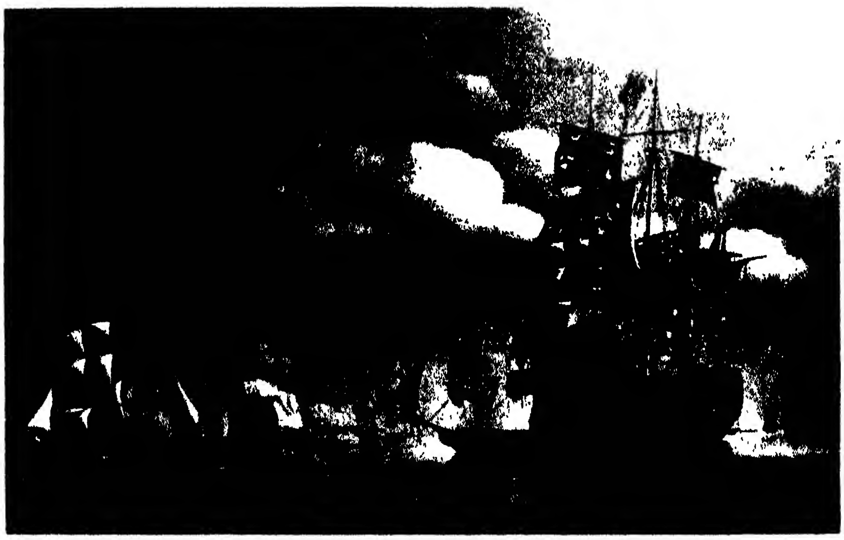
In due course, on April 1st, Lord Exmouth with his squadron of eighteen warships arrived at Algiers. He arranged peace for the Two Sicilies, the terms being that the Algerian Government should receive 24,000 Spanish dollars a year, and a regular number of presents, and Sicilian subjects then in captivity were to be released at the rate of a thousand dollars a head. Of a thousand captives 357 were released at once, and sent to Naples on board a British transport. A month or two later the ransom money, consisting of 364,000 Spanish dollars, was carried to Algiers and handed to the Dey.

Then an arrangement was made on behalf of Sardinia, her captives, forty in number, to be redeemed at the rate of 500 dollars a head, and her subjects to be placed on the same footing as those of Great Britain.

Finally the inhabitants of the Ionian Islands were recognised as British subjects, and the Dey undertook to release without ransom any captives of that nationality that might be held in servitude.

Lord Exmouth had foreseen that there might be trouble, and so while the negotiations were going on he had ordered Captain Ward, one of his commanders, to make a plan of the harbour and sea defences of Algiers, but to do this so secretly that the pirates should get no hint of what was going on. "Be cautious never to have any sort of paper about your person," said Lord Exmouth, "that may lead to suspicion."

The duty was carried out well, and the plans prepared proved very useful a little later on.



The bombardment of Algiers by the British in 1816. From the painting by M. Bauer

Lord Exmouth sailed from Algiers and went to Tunis and Tripoli, where he induced the rulers of those countries known as Beys to abolish the practice of Christian slavery altogether. Then he went back to Algiers to persuade the Dey there to do the same.

But this demand was indignantly refused. The Dey pretended that he had doubts as to whether Lord Exmouth had any authority to make such claims. He and his government became very insolent, and Lord Exmouth and the British Consul-General were insulted in the streets.

Further Humiliations for Britain

Soldiers were sent to the Consul's house and seized his horses, took possession of the building and treated his family with great rudeness. The Consul's wife, sister and daughter were driven into the town on foot in the most ignominious manner, and were threatened with prison.

Two British captains who had gone on shore were attacked and dragged off their horses. Their hands were tied behind their backs and they were marched through the town to the Dey's palace, but on arrival they were at once released.

Lord Exmouth sent messages to the Dey urging that the Consul and his family should be allowed to retire to the fleet in safety, but the Dey declared that this could only be permitted when the ransom money for the released British slaves arrived.

At last it was arranged that Algerine ambassadors should proceed to London, and also to Constantinople, to discuss the matter in dispute. It must be explained that though to all intents and purposes independent, the Dey and his subjects were supposed to be under the suzerainty of the Sultan of Turkey.

Lord Exmouth had no instructions to carry the matter further and so very reluctantly, and feeling the humiliation of the position for a great country like his own, he sailed away with his fleet for England.

But before the fleet left, the Dey of Algiers had sent notes secretly to two other ports, Bona and Oran, where the English had certain trading rights, largely carried out by Italians under British protection, and ordered the arrest of all the Italians there.

At Bona a large number of sailing boats from the Italian coast lay off the harbour, and their crews were on shore preparing to celebrate the feast of the Ascension by a high mass. The priest had donned his robes, the incense was already rising from the censers, when suddenly a gun was fired from the castle.

A crowd of furious Janissaries, or Turkish soldiers of a particularly ruffianly type, rushed down upon the scene, slaughtering the defenceless fishermen as they went. A hundred persons were murdered and as many more wounded, while 800 were taken prisoner.

The British Vice-Consul himself would have been killed had he not been saved through the personal friendship which the Governor of Bona had for him.

The British flag was torn down and trampled underfoot, the Vice-Consul's house was pillaged, and although the prisoners were soon afterwards released, their effects had been plundered.

This was a little too much. When the news reached England there was an outburst of indignation, and it was determined that the ruffianly Corsairs should no longer be negotiated with but treated with rigour.

Lord Exmouth was ordered to return at once and use any force he might

deem necessary to bring them to sense and reason. He sailed on the *Queen Charlotte* as his flagship, a vessel of 108 guns, and there were seventeen other vessels. At Gibraltar the fleet met a Dutch squadron of six vessels which solicited permisson to co-operate with the English. Permission was gladly given, and the united fleet arrived before Algiers on August 27th.

Before this a British troopship had been sent to endeavour to bring away the Consul-General and his family, but the Corsairs had heard rumours that a hostile expedition was on its way and the suspicions of the Dey were aroused.

The Consul's young wife and his daughter by a former marriage were safely smuggled on board disguised as midshipmen, but the wife had a young baby born in the previous year

"As," says one historian, "it is not customary for young gentlemen of the Royal Navy to carry little babies about with them, another stratagem had to be adopted. The surgeon of the vessel undertook to give the child an opiate, and as soon as it was fast asleep it was packed in a basket of fruit and vegetables to be carried on board as provisions. Unfortunately it began to cry when passing through the Marine Gate, and not only it, but the surgeon, three midshipmen, and the boat's crew of fourteen men were carried before the Dey "

The Dey Becomes Insolent

The crew were sent to the common prison, but fortunately the baby was allowed to proceed to the troopship --a solitary instance, Lord Exmouth remarks, of the Dey's humanity

The British Consul was kept in rigorous confinement The troopship left for Gibraltar, but meeting Lord Exmouth's fleet on its way to Algiers returned with it

As soon as he arrived Lord Exmouth sent a boat under a flag of truce with a letter to the Dey, demanding that the Consul as well as the officers and men of the troopship who were in prison should be released immediately and sent off to the fleet. He declared in this letter that he should hold the Dey responsible for any violence or insult that might be offered to the prisoners

The Dey, however, was insolent, and refused either to give up the Consul or to promise his personal safety, nor would he release the officers and men seized in the boat of the troopship.

Then a shot was fired at the English fleet from the Mole, and other shots followed This was promptly returned by the *Queen Charlotte* and the Battle of Algiers had begun. It is important, for it was the beginning of the breaking up of the power of the Algerine pirates.

The Dutch admiral had taken the station assigned to him and joined in the attack on the hostile batteries. It was one of the fiercest battles of the kind that had taken place up to that time. The expenditure of ammunition by the British fleet broke all records The fleet fired nearly 118 tons of powder, 50,000 shot weighing more than 500 tons, nearly 1,000 shells, beside other missiles known as rockets and carcasses

Thousands of Pirates Slain

In the British fleet 128 men were killed and 690 wounded, while the Dutch had 13 killed and 52 wounded. Among the pirates the killed and wounded are said to have numbered between 6,000 and 7,000 men.

Lord Exmouth himself was slightly wounded in three places, and his telescope was broken in his hand The

The Dey had to make public apology to the English Consul

Arabic interpreter on the *Queen Charlotte* wrote: "After the battle it was indeed astonishing to see the coat of his lordship, how it was all cut up by musket balls behind, as if a person had taken a pair of scissors and cut it all to pieces "

The Dey had received his lesson The next day he agreed to a treaty of peace ratifying all former conventions, agreeing that in the event of future wars with any European power none of the prisoners should be confined to slavery, but treated as prisoners of war until exchanged, and that at the end of hostilities they should be restored to their countries without ransom. The practice of condemning Christian prisoners of war to slavery was for ever renounced.

Lord Exmouth also insisted that all Christian slaves in the dominion of the Dey, no matter to what nation they belonged, should be at once released, and to this the Corsair chief agreed As a result 1,642 captives of a dozen nationalities were sent on board the British fleet Among them were 18 Englishmen. These, with the captives who had been liberated just before at Tripoli and Tunis by the exertions of Lord Exmouth, made a total of 3,003.

The Dey was also compelled to hand back all the sums of money he had received from the Italian states since the beginning of the year, and these amounted to 398,500 Spanish dollars

Finally, the Dey had to make a public apology in the presence of all his ministers and officers to the English Consul, and was compelled to beg the Consul's pardon in terms dictated by Captain Brisbane of the *Queen Charlotte*

This unfortunate Consul had suffered severely For weeks he had been imprisoned and given only one meal a day On the day of the bombardment he was dragged half naked with his hands tied behind his back to a prison in the town, where he was confined in a dilapidated dungeon, chains being riveted on his wrists and ankles and fastened to a staple in the wall

End of the Corsair Rule

It was curious that the removal of the Consul from confinement in his own house to a prison probably saved his life, for not long after he had left the house a number of shots passed through the room which the Consul had lately occupied

This bombardment sounded the knell of the Corsair rule As the American Consul who was in Algiers during the bombardment wrote: "The moral effects of the battle which are perceptible are total discouragement and despair on the part of the natives, and rage and mortified pride on that of the Turks They have long cherished, and not without reason, a belief of their superior prowess by land and sea, and within little more than a year they have seen the complete practical refutation of both these absurd theories." The latter sentence refers to the action of the American fleet the year before.

The next year the Dey was strangled by his soldiers. This was the usual fate of the Deys of Algiers. Some of them indeed reigned only for a few days before meeting a violent death

It took another British expedition in 1824 and finally the French conquest a few years later before the Barbary pirates were reduced to impotence. But it is gratifying to know that the chief instrument in their downfall was the fleet of Lord Exmouth, and that when England thus acted it acted on behalf not only of the British nation, but of the whole Christian world

THE BEGINNING OF A MIGHTY RIVER

The Nile is the longest river of Africa. Among the world's rivers it is exceeded in length only by the combined Mississippi-Missouri. The latter is 4,194 miles long, whereas the Nile is about 4,000 miles. In this photograph we see the beginning of Africa's mighty river. It rises in the great Victoria Nyanza Lake, and begins by the waters leaving the north end of that lake and pouring over the Ripon Falls. The source of the Nile was long a matter of doubt, but its origin was discovered in 1858 by John Hanning Speke. Sometimes smaller rivers that run into the Victoria Nyanza are spoken of as sources of the Nile, but it is the lake itself which is the real source

THE WAY IN WHICH A RIVER BEGINS

Rivers are of all sizes and vary a great deal in their courses. Some flow steadily and evenly, winding about as they go, others rush as torrents down mountain-sides, and others cut their way through rocky chasms. No matter what the character or size of the river may be, it owes its water to the moisture in the atmosphere. Sometimes this falls as rain, and sometimes as snow. Whichever it may be, it eventually finds its way into some water-course, as explained here

ALL rivers, even the longest and mightiest, have a beginning, but the start is not always the same. Sometimes, as in the case of the Nile, the river starts by a great volume of water pouring out of a lake. In this way the Nile originates in the great African lake, the Victoria Nyanza, as shown in the picture on the opposite page.

But most rivers start in other ways. Some begin where a glacier ends and melts. A glacier is, of course, a frozen river, and so if the ice melts and continues its course down the mountain or along the valley, the river may be said to begin either where the melted water of the glacier starts pouring down the course, or where the glacier itself begins higher up the mountain by the snow being pressed together and set sliding down the mountain-side.

A river which owes its origin to a melted glacier

A river beginning as a spring pouring from a mountain side

A river that starts by the uniting of many little streamlets

A river beginning with water that pours from a lake

Then there are rivers which begin as little springs bubbling out of the hillside. The rain that falls upon the Earth percolates through the soil, and when it reaches a layer of non-porous rock through which it cannot trickle it begins to run down the slope and may eventually escape as a spring on a hill or mountain-side. This then cuts out a course for itself, is joined at various points by other little streams, till eventually a river is formed, and makes its way into another river, a lake, or the sea.

Many rivers, however, begin in none of these ways. When the rain falls the ground water which does not sink through the soil immediately begins to run to a lower level, and in doing so forms a whole series of tiny streamlets. We can see this in the garden after heavy rain. Water trickles to the lowest level in all sorts of directions. Well, the same thing happens in the open country and gradually the hundreds of little streamlets run down until they unite and form a water-course sufficiently big to be dignified with the name of brook or burn. As this continues its course other streams run into it, and so the river is formed.

Streams are always more numerous in regions where the rainfall is plentiful than they are in areas where rain is scarce. Streams are swollen after rains, but in times of drought many of the small water-courses dry up altogether. If the land were perfectly even, the water would flow not in streams, but as one sheet.

THE MEANING OF ISOBARS AND ISOTHERMS

It is, in some ways, a pity that such technical-looking words are used by men of science for quite simple ideas. We find examples of this in all the sciences, as when the flower of a plant is called an inflorescence.

In the weather report, which more and more people now study, we often find the two very Greek-looking words "isobar" and "isotherm."

They are really quite simple words, and stand for simple things which all can understand "Iso" is from a Greek word meaning "equal," and "baros" is a Greek word meaning "weight." "Isobar" therefore means "equal weight," and it is simply a line drawn on a map connecting places at which the barometer has the same average height, that height being due to the weight of the atmosphere pressing on the barometer. For the purposes of drawing the line or isobar, the barometer readings are worked out at what they would be if the places were all at sea level.

"Isotherm" means "equal heat," "therme" being the Greek word for "heat." Isotherms are lines on a map showing places which have the same average annual temperature.

There are other words used by weather scientists in which "iso" is used. Isohels, for example, are lines showing equal duration of sunshine, "helios" being the Greek word for "sun," and isohyets are lines showing equal amounts of rainfall, from "hyetos," the Greek word for "rain."

It is interesting, in studying a weather map on which isobars are marked, to notice that there is a distinct relation between the wind and the isobars. The wind blows from a region of high pressure to one of low pressure, and its direction is generally round the isobars, with the lower pressure on the left. The wind is always strongest where the isobars are most closely crowded together.

In preparing a record of isotherms, as in the case of the isobars, many readings are taken in different parts of the country, and from these various observations the normal monthly and annual temperatures are computed.

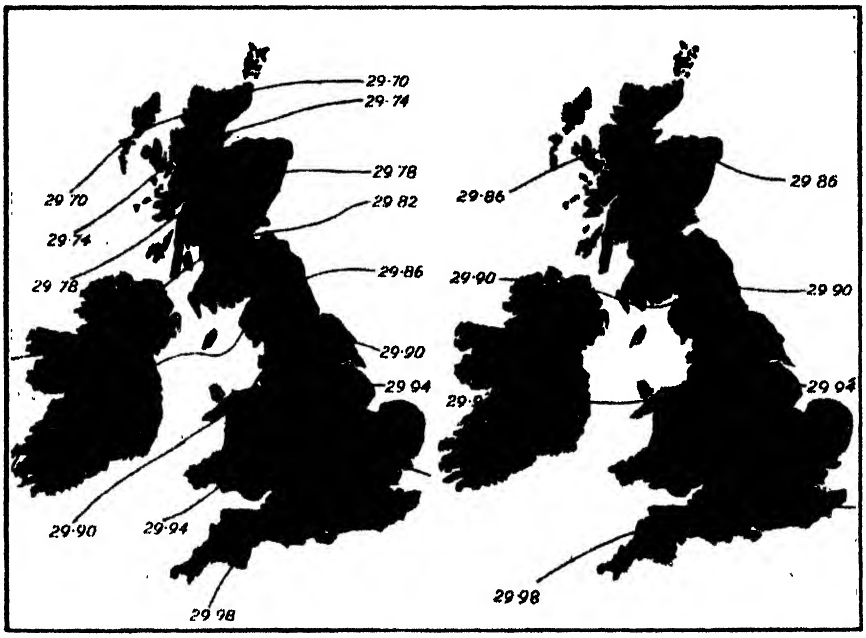
It is interesting to notice on the maps how the direction of the isotherms varies between summer and winter. In January the lines have a mainly vertical direction, whereas in July they approach the horizontal.

Temperature varies at different heights above the sea level, and in order that the observations may be uniform in character, the thermometer readings are all reduced to what they would be at sea level.

Observations are made by vessels at sea, in order that the isotherms may be continued from the land on to the sea.

The way in which isotherms vary on a map may surprise us. As we know, all places with the same latitude receive the same amount of heating by the Sun, and if there were no outside influences to affect these all the places on the same parallel of latitude would have the same temperature. The isothermal lines would in that case be parallel with the parallels of latitude. But they are far from this.

What is the reason for the variation? Well, there are many causes, but the chief is the existence of ocean currents. These currents depend upon the temperature differences between different parts of the Earth, the permanent winds of our globe, the evaporation, which is greater at some parts of the ocean than at others, the varying degrees of saltness and those of density, the Earth's rotation on its axis, and the shape of the coastline. All have their influence in affecting the currents, and the currents affect the temperature. Round the British Isles, and in Scandinavia, as a result of the Gulf Stream drift these lands are warmed and the isothermal lines are carried far to the north.



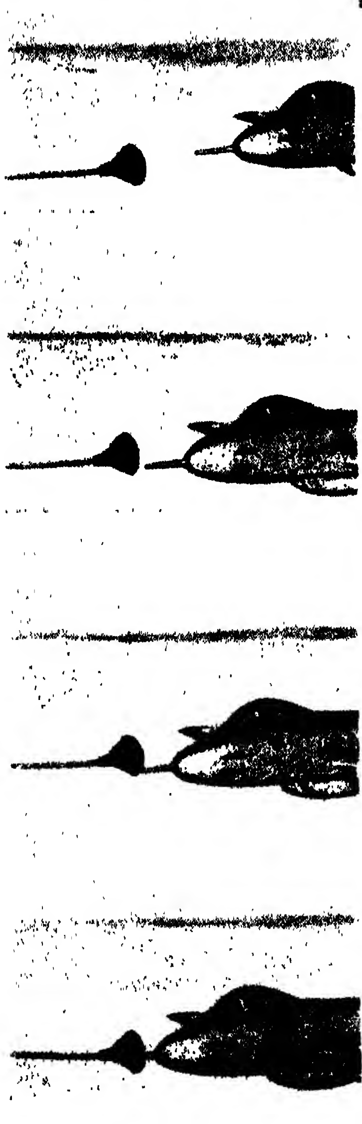
Two maps of the British Isles showing the isobars in January and July, that is the lines joining up places of equal barometric pressure, where the barometer reads the same

Maps of the British Isles showing the isotherms of January and July, that is the lines joining up places where the thermometer readings are the same

WHY A TORNADO IS SO DESTRUCTIVE

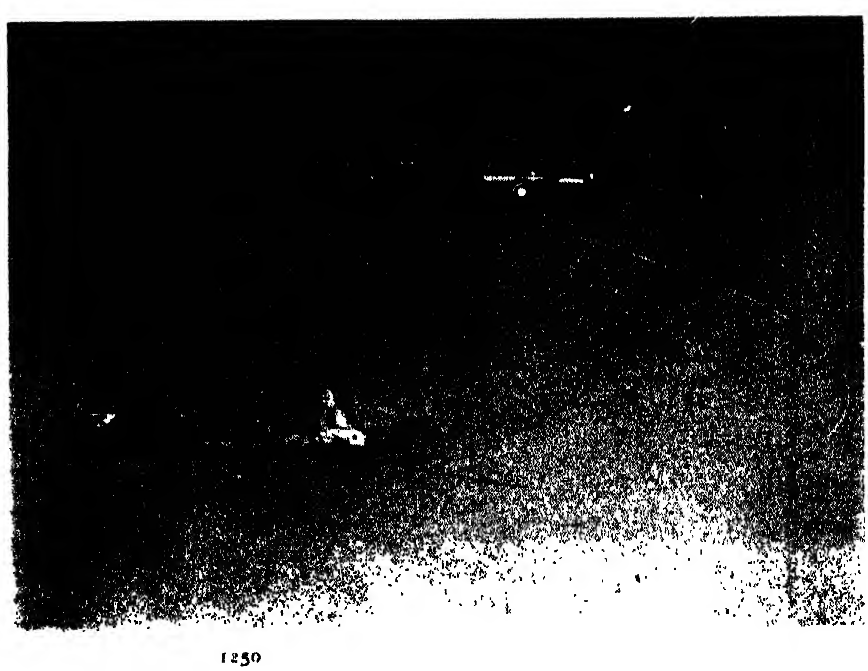
A tornado is the most destructive of all storms, and when one passes it cuts down trees and telegraph poles and fences and houses, as though a gigantic scythe had been at work. The tornado is a spiral wind whirling round at terrific speed. It is said that sometimes the speed of this rotating wind is as much as 500 miles an hour. The great funnel of spiral wind travels across country at anything from twenty to fifty miles an hour. The diameter of the tornado is generally less than a thousand feet, and it leaves behind it a strip of devastated country of that width. As the wind whirls round it cuts down everything in its way with strange results. One side of the funnel of wind will strike a fence or a plantation and throw down everything in one direction, and then when in its rotation it strikes the fence again everything is blown down in the opposite direction. A vacuum is created in the centre of the whirling wind with the result that buildings explode outwards, the pressure of the air in the rooms forcing the walls out into the vacuum. Records for ten years show that in the United States the average annual number of tornadoes was 146. In regions where they are likely to occur the people in many cases prepare what are known as cyclone cellars, in which they take refuge during the passage of the storm

FLYING FILLING-STATIONS FOR AIRCRAFT



The range of an aircraft is the farthest distance to which it can fly on one load of fuel, and the range of any given aircraft is limited by the combined weights of its fuel and payload. A civil aircraft's payload is made up of the weight of its crew, passengers, and cargo ; and the payload of a military aircraft is the combined weights of its crew and armament. The only way an aircraft's range can be increased without reducing its payload is by refuelling the aeroplane when it is in the air. This is done by the ingenious system of flight refuelling developed by Sir Alan Cobham, who realised the need of some such method of increasing range when he established in the 1920s and 1930s an impressive list of long-distance records

When an aircraft has flown part of its journey and the greater quantity of its fuel is used, it is met by a flying tanker which fills its tanks. This can be done in two ways. One is for the tanker aircraft to trail from its supply tank a hose having at the end a cone into which the aircraft to be refuelled pushes a nozzle, called a probe, mounted in its nose. The photographs on the left show the probe of an aircraft needing fuel being manoeuvred into the tanker's cone. Immediately cone and probe are connected, fuel flows from the tanker. When his aircraft has been refuelled, the pilot of the receiving aircraft slackens speed and probe and cone are disconnected. The photograph at the top of the page shows how three fighters can be refuelled simultaneously from one tanker. Below is an illustration of the second flight-refuelling system. The flying tanker drops a hose which is taken on board the aircraft short of fuel and connected to its empty tanks. This method is for low-speed aircraft



THE ASTONISHING WORK THE HEART DOES

The heart is not very big, just about the size of the closed-up fist, yet the work it manages to do in the course of a day is truly astonishing, as we read in these pages. No machine that man can make compares with it in efficiency, but like all machinery it must be treated with care if it is to continue working well

The heart is the most efficient pump that exists anywhere. We have seen in another part of this book (page 1051) how it drives the blood through every part of our body, and we may wonder how long it takes for any particular portion of blood to circulate; that is, how long it is from the time the blood leaves the heart to the time it arrives back once more. Well, the period occupied in the passage of the blood from the heart through the arteries, capillaries and veins, back to the heart again, is 22½ seconds; in other words, the entire blood of our bodies passes through the heart in 22½ seconds.

To work at this rate, the heart must of necessity be a very powerful pump. The whole force which it exerts is equal to the lifting every hour of nearly two and a half tons a height of one foot; or, to put it another way, the force which the heart exerts is capable of lifting its own weight 11,000 feet, or over two miles every hour. This is really an astounding amount of work for such a small-sized pump to do.

How you may listen to the sound of your own heart with a home-made stethoscope, formed from a tobacco pipe and a length of india-rubber tubing

A Mighty Pump

An active, powerful man can raise himself 1,000 feet in an hour, and the work a locomotive does is equal to raising itself nearly 3,000 feet in an hour. What a puny thing, in proportion to its size, is a railway engine when compared to the human heart!

The pumping of the heart is, of course, done by the contraction and expansion of the muscular walls, and the complete movement takes less than a second. Some people think that the heart works without ceasing, but this is not the case. It does not, however, work continuously for a long period and then take long rests; it rests in between its movements The whole movement of contraction and expansion occupies four-fifths of a second, but during half this period the heart takes a little rest, so that really, through the 24 hours, 12 hours are spent in actual work and 12 hours in rest.

When the heart contracts—that is, when the walls press in, squeezing the blood out into the aorta, or big artery—the movement is called the systole, a Greek word which means "contraction." When the walls expand and return to their normal position once more, the movement is called the diastole, which is a Greek word meaning "a drawing asunder."

As the walls of the heart move to and fro doing their pumping work, we can, if we place our ear to a person's chest, hear two distinct sounds at each beat of the heart, followed by a pause The sounds are something like the syllables "lub," "dup," the first sound being low-pitched and prolonged, while the second sound is high and sharp. We may hear the sounds better if we make a simple stethoscope for ourselves, something like that which the doctor uses when he is listening to our heart. The name stethoscope is from two Greek words meaning "breast examiner."

Buy a cheap cherry-wood tobacco pipe and cut the stem in half; then join the two ends together by means of a piece of rubber tubing about 15 inches long Now place the bowl of the pipe over your own heart and the mouthpiece of the stem in one of your ears You will distinctly hear the heart at work—lub, dup, pause; lub, dup, pause, and so on.

We read on page 1051 what the heart is like; how it consists of four chambers, two known as auricles and two as ventricles. When the heart is working the two auricles contract at exactly the same moment, and the blood in them is forced into the two ventricles Then the two ventricles contract together, and the blood is forced into the arteries. After that the heart rests for nearly half a second.

The Heart and Its Beats

The number of times the heart beats in this way varies in different people, in the two sexes, and at different periods of life. In the new-born infant the heart beats from 130 to 140 times per minute When the child is one year old, this is reduced to 120 to 130 per minute; then, a year later, it is 105, and at three years of age only 100. At four the heart-beats are 97 in the minute, and from five to ten years, about 90. At the latter age they are generally reduced to about 78, and from the fifteenth year to the fiftieth they are from 70 to 72. At sixty years of age the number of beats in the minute generally increases a little to about 74, then, at eighty, the number is reduced to about 70, and afterwards gradually increases to about 80.

The walls of the arteries are very elastic; that is, they can be stretched and will return to their former shape and size. When the blood passes along at each pump of the heart, the artery swells a little and is lifted slightly, just as a garden hose, lying on the

ground, jumps when the tap is turned on, or at each stroke of a pump that forces water through it. This throb in the arteries is called the pulse and it can be felt in various parts of the body, as in the wrist, the temple and the inner side of the ankle. We can also feel the heart beating if we put our hand on our chest

The normal rate of the pulse is about 71 or 72 per minute in a grown person, corresponding, of course, to the beats of the heart. But it is greatly influenced by our actions, as well as by our age, and it is raised by warmth and diminished by cold applied to the surface of the skin. It increases a little when we are taking food. There are, of course, exceptions to the normal average rate, and healthy persons have been found with pulse rates of only 30 a minute, while in others the rate has been as much as 120 a minute. The pulse in women has about eight beats a minute more than that in a man of corresponding age.

There is no pulse in the veins, as the blood, being farther from the heart's pumping force, is not streaming in waves, but flowing steadily. In the aorta the blood rushes along at the rate of about 15 inches a second. In the arteries it travels along at about a foot a second, but in the capillaries speed is greatly reduced, and there the blood travels at only about an inch a minute. In the veins the speed once more increases and flows towards the heart at about an inch a second. The force with which the heart pumps the blood into the arteries would cause it to travel at 200 feet a second if the arteries were rigid, like glass tubes; but owing to their elastic nature, so that their walls yield, the speed is slowed down to a foot a second.

The left ventricle pumps into the aorta, or large artery, about three ounces of blood at each contraction, and the pressure in forcing out this blood is sufficient to raise a column of blood five feet in height. The work done is equal to the throwing of a three-ounce weight five feet in the air, or the lifting of 15 ounces one foot.

The total work performed by the heart of an ordinary man during one day is equal to the raising of 126,000 pounds, or over 56 tons, a distance of one foot.

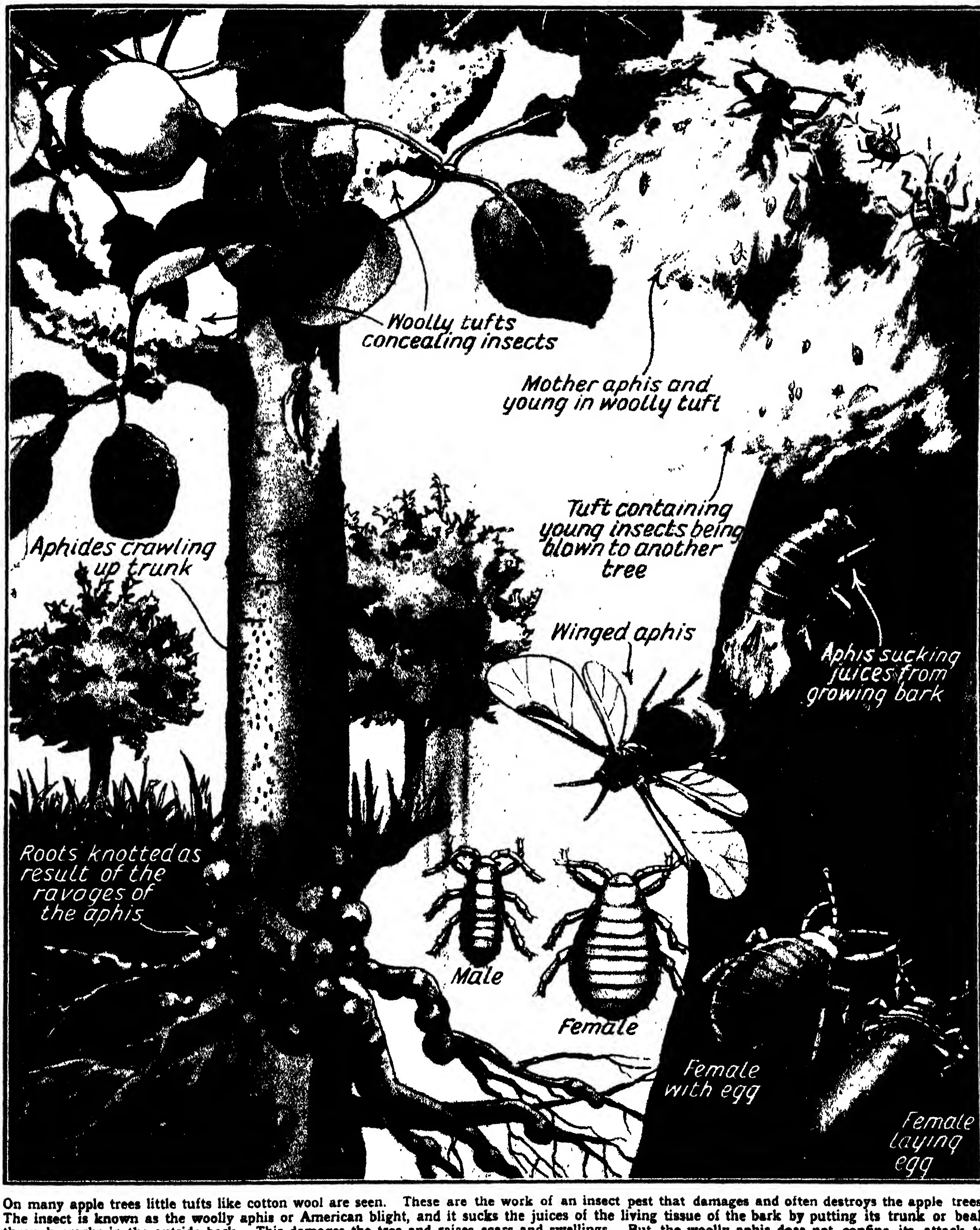
No engine ever devised by man has proved anything like so efficient as this.

If by misfortune we happen to cut an artery, the blood flows out; but the flow is not uniform and smooth. It takes place in jerks and these correspond to each beat of the heart Further, the blood spurts out with a good deal of force, and this is a proof that the blood in the artery is under considerable pressure

THE DINGO OR WILD DOG OF AUSTRALIA

The dingo or wild dog is the highest type of native animal found in Australia and it exists nowhere else in the world. Some scientists think that it is not really a native at all, but must in some way have reached the island continent from Asia. The dingo is about the size of a wolf and varies in colour from reddish brown to greyish black. It preys on the farmer's sheep and relentless war has been waged against it till, in some districts, it has become almost extinct. The kangaroos have thereupon multiplied, eating the pasturage wanted for the sheep, and they in turn have had to be destroyed

THE LIFE-STORY OF A GREAT INSECT PEST



On many apple trees little tufts like cotton wool are seen. These are the work of an insect pest that damages and often destroys the apple trees. The insect is known as the woolly aphis or American blight, and it sucks the juices of the living tissue of the bark by putting its trunk or beak through cracks in the outside bark. This damages the tree and raises scars and swellings. But the woolly aphis does not confine its attack to the bark. It is found all over the tree, particularly on the roots underground, where it does most damage. The swellings there result in decay. The foliage also is infested and becomes yellow and sickly. The life-story of the woolly aphis is a strange one. During the summer wingless females appear and bring forth from two to twenty living young a day. These are concealed in the wool-like threads produced by the body. They feed and grow and hibernate in cracks of the bark during winter. In autumn winged females are produced and fly from tree to tree. They produce from six to twelve young, about half being males and half females, which mate, and each female then lays one oval egg nearly as large as her body. This hatches out in the spring, and soon colonies of aphides appear surrounded by the woolly growth and the life-story begins all over again

A POWERFULLY ARMED FISH FAMILY

There is a well-known family of fishes related to the sharks and known as the rays, which are very unpleasant creatures to meet. The fact that they have such names as devil fish, sting ray, thorn-back ray and torpedo or electric ray is a proof that they are not exactly the friends of man.

In the sting ray the long slender tail is armed with a formidable spine that has saw-like edges. This spine is often eight inches in length, and from time to time it is shed by the fish, which grows a new one in its place. The sting ray, of which there are many species, is abundant in the Indian and Atlantic Oceans, and is also found in the Pacific. Fishermen sometimes take it off the southern coasts of England.

It is a large fish with a body often three feet long and a tail of a foot and a half. When it lashes this tail about, the serrated spine becomes a terrible weapon, and inflicts very serious wounds. One man who is said to have stolen a sting ray from a fisherman's net, mistaking it for a turbot, concealed it about his clothes and while pressing it close drove the spine or dart into his body and killed himself.

Another of the family known as the eagle ray or devil fish, found in tropical and temperate seas, grows to a length of eighteen feet and a weight of half a ton. It has a pair of horn-like attachments used by the fish to draw its prey into its mouth. This mouth opens like a huge cavern, and as the eagle ray swims along it often keeps this mouth open and flaps its sides, thereby drawing in many of the smaller crustaceans on which it feeds.

To capture this monster is a dangerous and difficult task. It can easily overturn a boat, and it becomes very ferocious, especially if the fish happens to be a female accompanied by its single offspring. It has a long whip-like tail armed with a long barbed spine capable of doing much damage, and when it is captured it lashes this tail in all directions and inflicts a severe wound on anybody it may hit.

One of the commonest of the rays, a fish valuable for food, is found in British waters and is known as the thorn-back ray. This measures from two to three feet across the body and has a tail eighteen inches long. Along this tail there are three rows of stout spines, the middle one running up the back of the fish, and these can make a nasty wound.

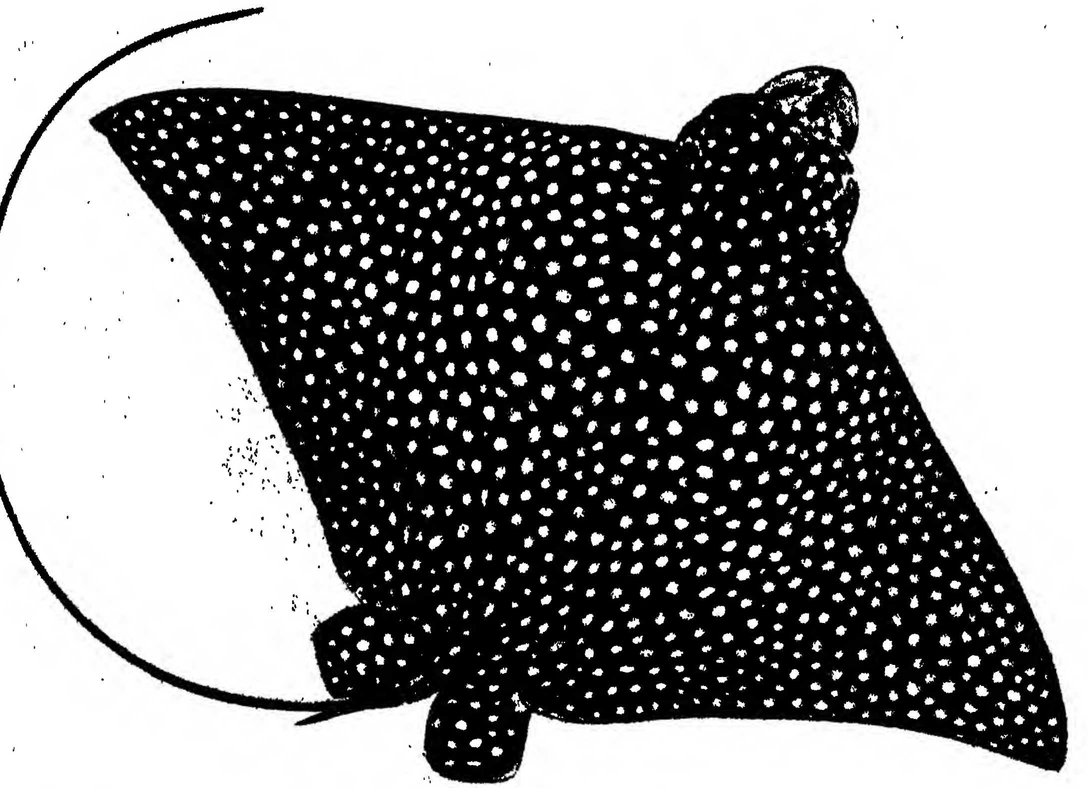
A still better armed, though rarer member of the family, is the starry ray, which has formidable thorns all over its body as well as down its tail.

Perhaps the most interesting member of the ray family is the electric ray. It has a strange method of defence, for when it is attacked or excited, with its tail it gives the enemy an electric shock which stuns the foe if it is large and kills it if it is small. An electric ray measuring only two or three feet across the body is said to be capable of disabling a man by the discharge of its electric battery.

This fish is found from time to time in English waters. Its general shape is that of a ray or skate, but its skin is soft, and there are no spines about its body. It is very flabby to the touch, and indeed feels like a piece of wetted wash-leather. The colour is a dark chocolate. It weighs from thirty to forty pounds. The teeth of the torpedo are very small, and there seems little doubt that its electric power is used for killing its prey.

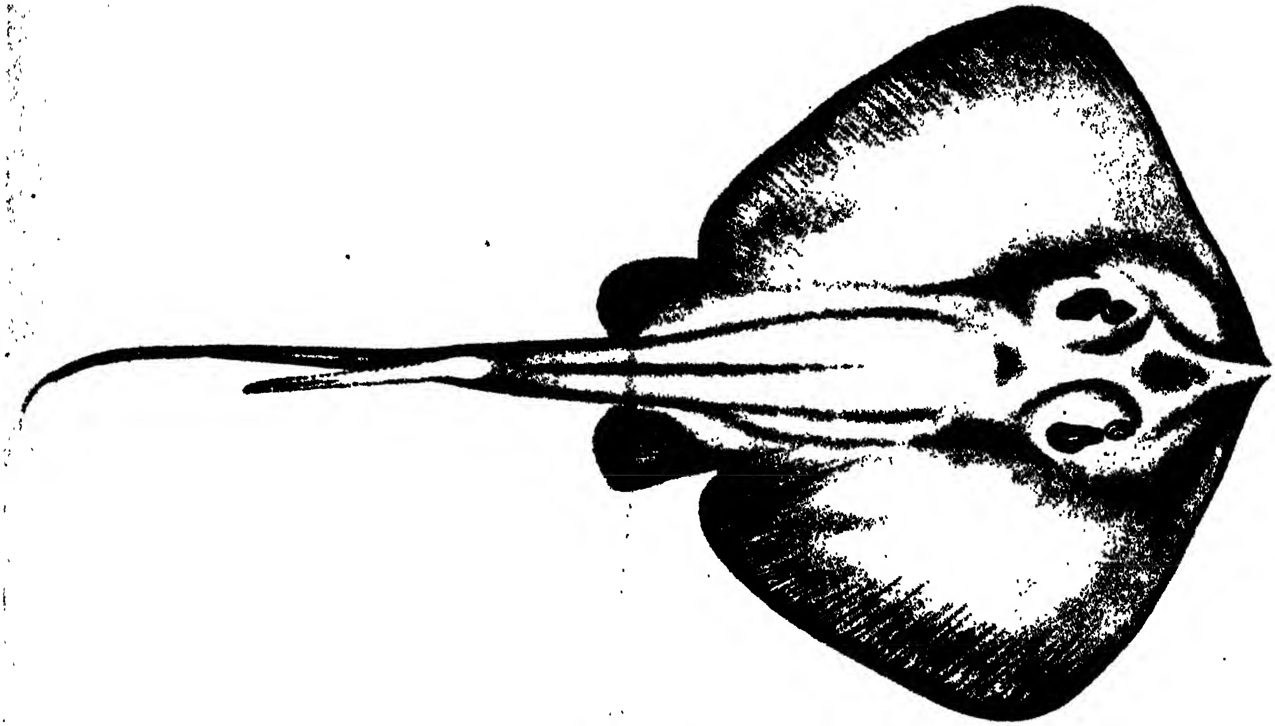
The electric organs are on each side of the head, and are made up of six-sided or five-sided prisms something like a honeycomb. The prisms are divided across at short intervals by partitions forming a number of cells, and these contain a jelly-like liquid consisting of nine parts of water to one of albumen. These cells seem to correspond to the cells of an electric battery. As many as 1,182 prisms have been counted in a large torpedo. A fisherman standing on the wet ground and pouring a stream of water from a bucket on to a torpedo would form a circuit through the stream, his body and the earth, and would probably feel a slight electric shock.

The current is not continuous, but

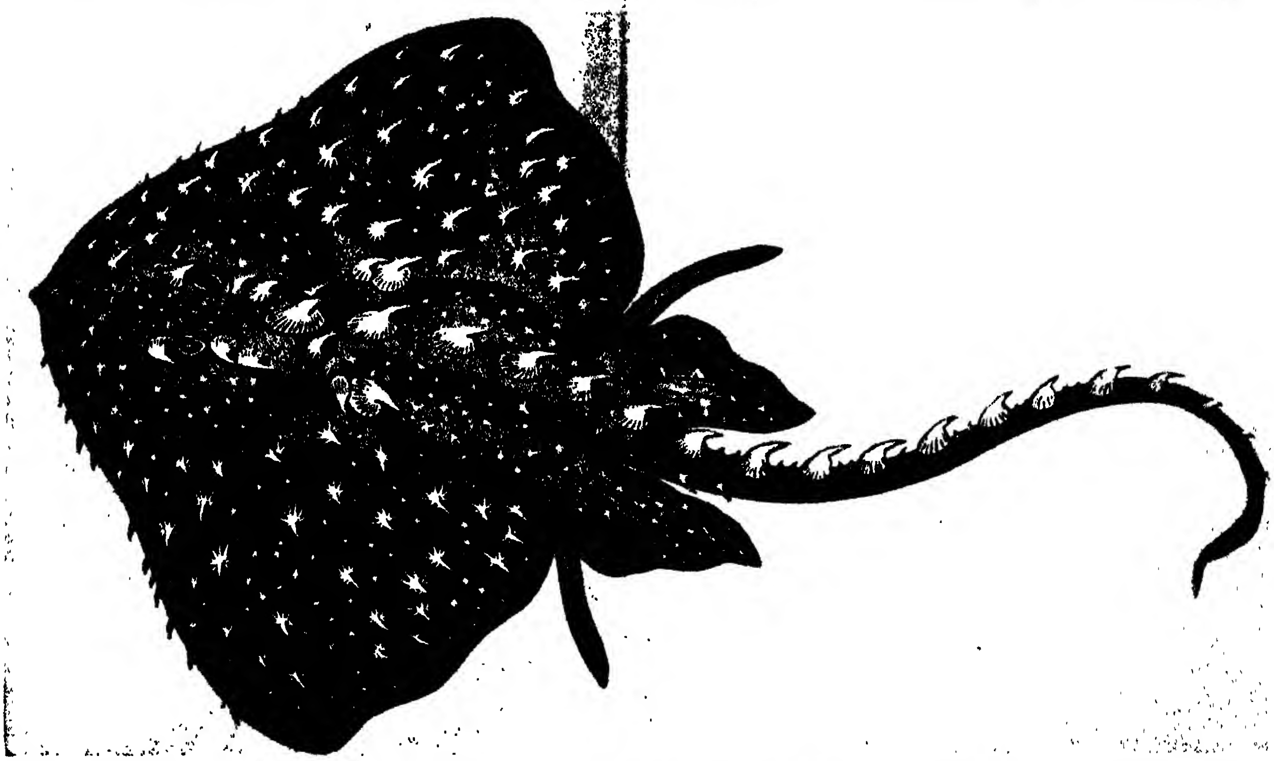


The spotted eagle ray which when captured flourishes its tail in all directions and inflicts serious wounds on anyone it may strike

FISH WELL-ARMED TO MEET THEIR FOES



Many of the fish known as rays are very dangerous, for they are armed with formidable weapons which they do not hesitate to use. Here, for example, is the Sting ray. It has a kind of dart with saw-like edges on its tail, and with this it can inflict a very serious wound, which often becomes inflamed and may lead to death from lockjaw. The Sting ray grows to a length of about three feet, and the tail sometimes measures about two feet. When attacking an enemy the fish twists its long tail round the foe and tears his flesh with the serrated spine Fishermen, to protect themselves from attack, cut the tail off directly they catch the Sting ray



Here we see the Starry ray, which somewhat resembles the Thornback ray, but has far more formidable spines on its back. The spines can inflict very nasty injuries, especially as the fish is very muscular and can lash its tail about in all directions. The spines are exceedingly sharp, and there is no doubt that they have been developed by the fish like the dart of the Sting ray, as a means of defence against enemies. Such defence is necessary, because the rays have many foes. Another ray, known as the Torpedo or Electric ray, gives an electric shock that numbs a human being and kills other fish, as does the electric eel described in page 228.

flows in a series of waves one hundred or more to the second. The exact origin of the electric current in the torpedo is still a mystery to scientists. Warmth helps the current while cold reduces it. The largest species of electric ray has about a million cells in its two electric organs.

After giving a certain number of shocks, the battery runs out and the fish requires rest in order to accumulate more electricity.

While the electric shock which the torpedo is able to inflict is a useful form of defence, Mr. Frank Buckland, the authority on British fishes, has stated that his own idea is that the electric power is possessed by the fish to kill its prey.

"I can see," he says, "no other way that the poor thing has to procure its living. The teeth of the torpedo are exceedingly small and certainly not suited to the capture of any vigorous or lively prey; the appearance of the fish is that of a skulking rascal; his coat is also mud colour. He is probably too lazy to hunt after his own food, and doubtless remains half asleep in the mud till something worth eating walks upon him or swims over him; he then lets fly and gets his dinner without much difficulty."

As to the food of the torpedo, specimens have been opened. One contained an eel two pounds in weight, and a flounder of nearly a pound, and another contained a salmon between four and five pounds in weight.

The rays are relations of the skates, and have the same general shape of body. An interesting thing about all these fishes is the curious form of the egg. Each egg is of oblong shape, something like the wooden tray with four handles in which the butcher's boy carries the meat. From each corner project two horn-like processes, and the total length, not including these horns is about eight inches, the breadth being three inches.

The shell of the egg is made up of a horn-like substance, and feels something like moistened leather, and is known as chitin. It is the same kind of substance as that which forms the horny wings of beetles. One end of the egg-shell is closed firmly, but the other end, when the young fish inside is ready to come out, opens, so that the fish can struggle through. At the end of the shell, where the door or opening is, there are two strings of the same material as the shell, and these intertwine and tangle, and they are used for anchoring the egg and at the same time they become guy-ropes enabling it to float in the water.

Directly the fish is hatched the empty shell floats away and specimens are often picked up on the shore by seaside visitors. Those found on the English coast are generally the shells of skate eggs and are smaller than the ray's.

HOW A TREE GROWS AFTER ITS WINTER SLEEP

Up to a point, all plants grow more or less in the same way; that is, by the cells multiplying and pushing out at the growing points of both stem and root. But, while many of the plants die off when winter comes, and in others the upper part of the plant perishes, leaving only the root-stock ready to put forth fresh stems in the coming spring, some, like the trees, merely sleep through the winter and begin growing again in spring.

Winter Sleep

We must remember that all through the summer the tree is absorbing moisture from the soil which passes up through the tissue of the tree and is given off into the atmosphere by pores in the leaves. Plants, like animals, live in a constant stream of water. Now when the winter comes and the ground is cold and sometimes frozen, it is very difficult, if not impossible, for the roots to absorb any water at all. Further, the low temperature reduces their activities, so that the operation by which the water passes from the root to the leaves is almost at a standstill.

Trees remain quiet through the cold winter and then in spring begin to grow. They increase in height and girth and put forth new roots and new shoots. But which part begins to grow first? Men of science have recently discovered that it is the shoots that grow some weeks before the trunk begins to increase in size

Now if through the winter moisture were to continue to pass off into the atmosphere from the leaves without any replenishment from the roots, the tree would dry up and perish. Nature provides against this, for with most of the trees she arranges for them to shed their leaves in autumn, and thus get rid of the immense surface through which the moisture passes into the air. In a sense, the tree goes to sleep for the winter and stops growing, just as a hibernating animal stops growing through its months of sleep.

In the case of evergreen trees which do not shed their leaves provision is made, for these leaves have tough, waterproof skins and they are generally small, as in the holly, thyme, and so on. The water is therefore unable to pass through them into the air.

Now when the warm sunshine comes once more in spring, and the tree begins to grow, which part grows first? As a well-known scientist, Dr. Slosson, has asked, does it first stretch out its fingers in the sunlight, or does it first let out its belt another hole, that is, grow longer before the trunk begins to grow bigger round, or is the order of growth the other way about?

Growing Branches

The experts of the Carnegie Institute in Washington have made very careful and very exhaustive experiments to find out the truth about this matter. They have instruments so delicate that they can measure any enlargement of the tree's trunk to the hundredth of an inch, and they can also measure similar minute extensions of the branches and twigs. They find that the tips of the branches begin to grow weeks and often months before the trunk shows any sign of enlargement.

WONDERS OF THE SKY

MAKING A DISTANT STAR WORK FOR US

Man is ever achieving greater marvels, but he has never done anything more wonderful than when he used the light of a star to operate the switches and light up a great exhibition. The story of this feat is told and illustrated on this and the next two pages

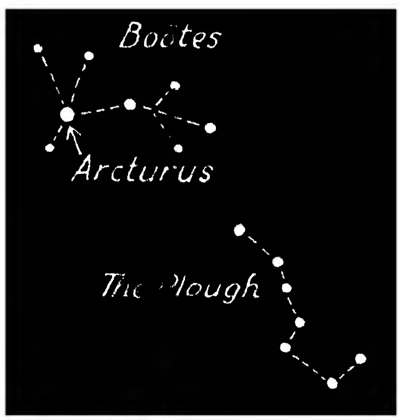
When the Chicago Exhibition of 1933 was opened, the astronomers and other scientists achieved a wonderful triumph They caught the light of a star, turned it into electricity and sent it a thousand miles across country to work the apparatus which should switch on the lights of the great exhibition.

The star was Arcturus, the bright star in the constellation Bootes, and the ray of light which did the work started on its long journey through space during the time that William the Fourth was reigning in England.

On came this ray of light travelling at 186,000 miles per second till at last it was trapped by a big telescope at Harvard University Observatory in Massachusetts. It was also caught by telescopes in three other universities, the Yerkes Observatory at Geneva in Wisconsin, the Allegheny Observatory at Pittsburg in Pennsylvania, and the Illinois Observatory at Urbana.

The star's light was in each case reflected from the telescope into a photo-electric cell where it generated a weak current of electricity. This was amplified sufficiently to operate a telegraph instrument and send a message across the land lines to Chicago.

When the message from the star's light through each observatory had reached the exhibition a circuit was completed and a switch turned on which caused the great searchlight of the exhibition tower to shine. The mechanism also turned this light round gradually so as to shine upon all the various buildings, and in these photo-electric cells changed the light into electricity and switched on the lamps.



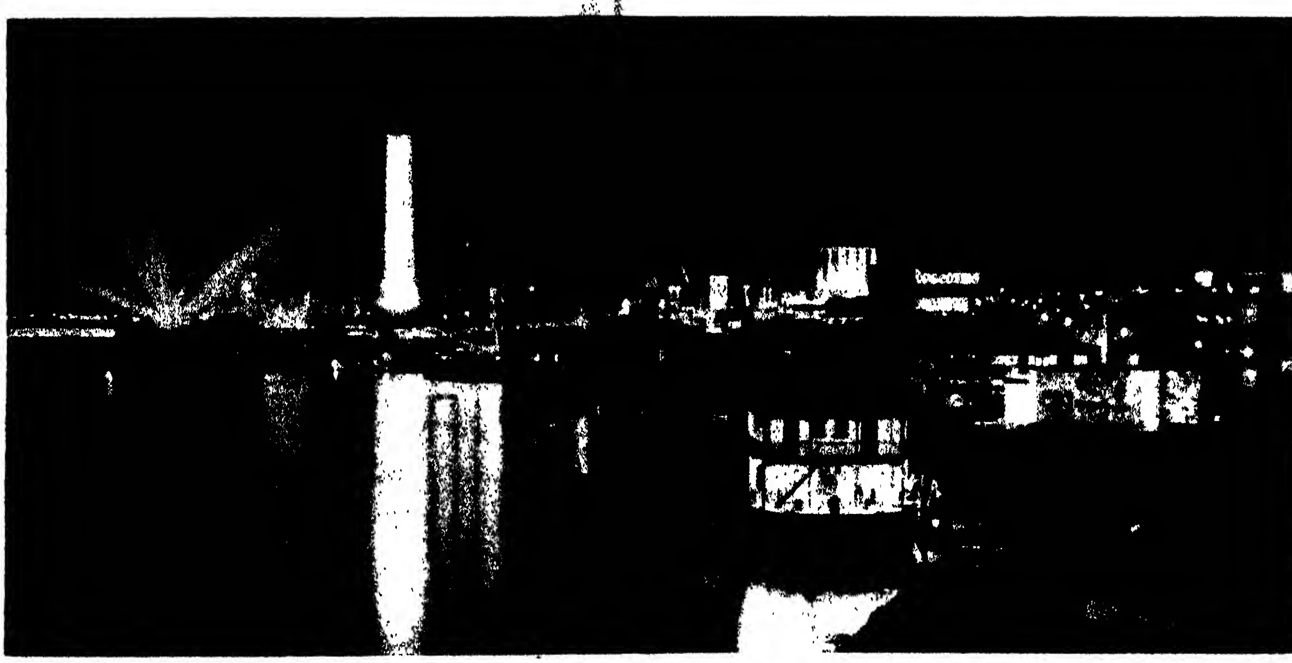
The star Arcturus, in the constellation Bootes near the Plough, which switched on the lights of the Chicago Exhibition

Arrangements had been made at four observatories to catch the light of Arcturus in case by any chance there should be a cloudy sky over some of them The astronomers made more than doubly sure of getting their motive power to light up the exhibition

On the next two pages Mr. L. G Goodwin shows us in simple form how this marvellous achievement was brought about.

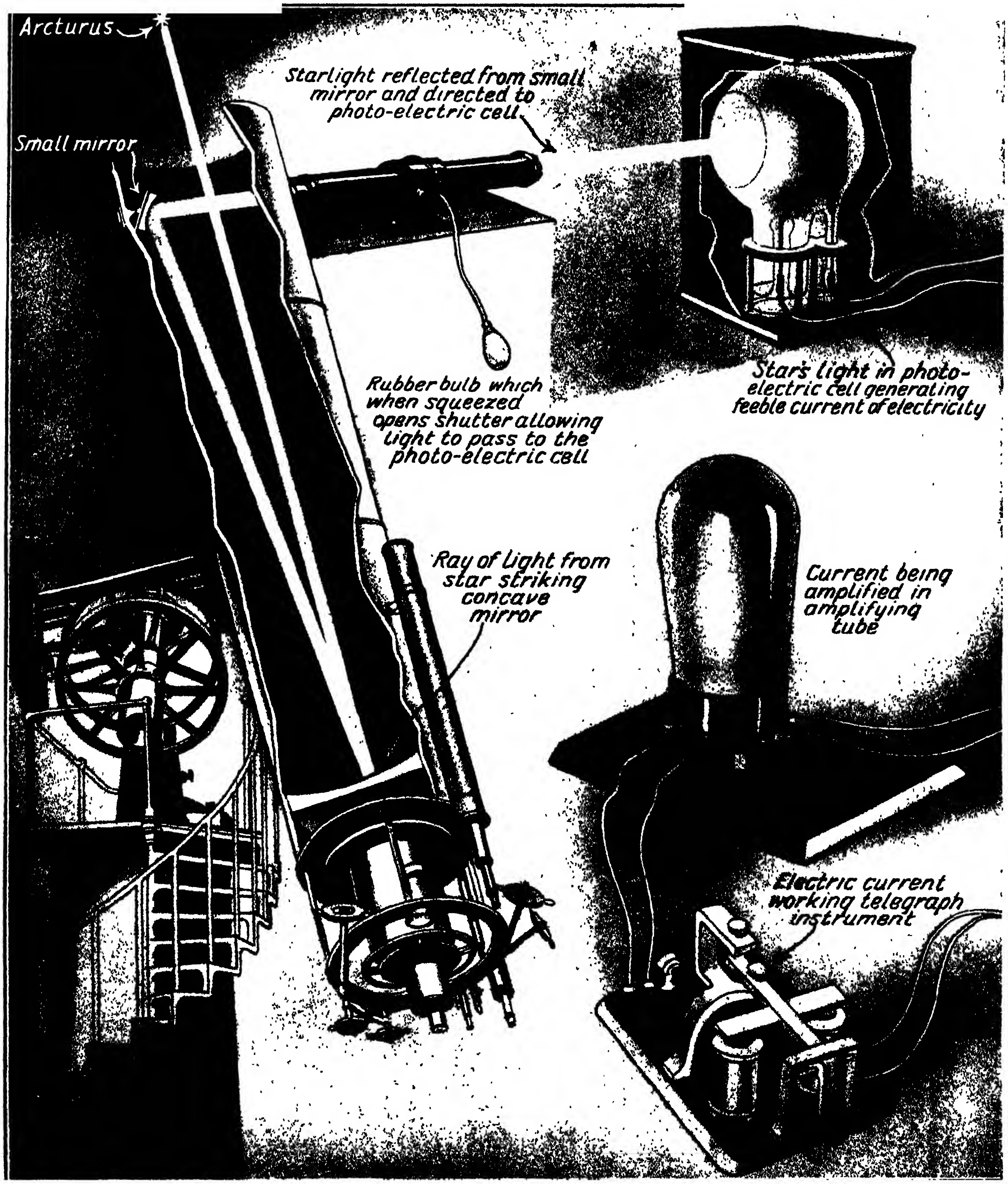
Generally some distinguished person, like a king or president, or prime minister, opens an exhibition by pressing a button, but in this case a star's light was used for the purpose.

Man has often made use of the Sun's light to work for him, but this is the first time that the light from a distant star has been harnessed and used in such a wonderful way. Without a photo-electric cell it would, of course, have been impossible to change the light into electricity, and without the amplifiers it would have been impossible to make the current strong enough to work the telegraph instrument. It was by the combination of the telescope, the photo-electric cell, the amplifier, and the telegraph, all directed by the marvellous brain of man, that this wonder was accomplished so triumphantly.



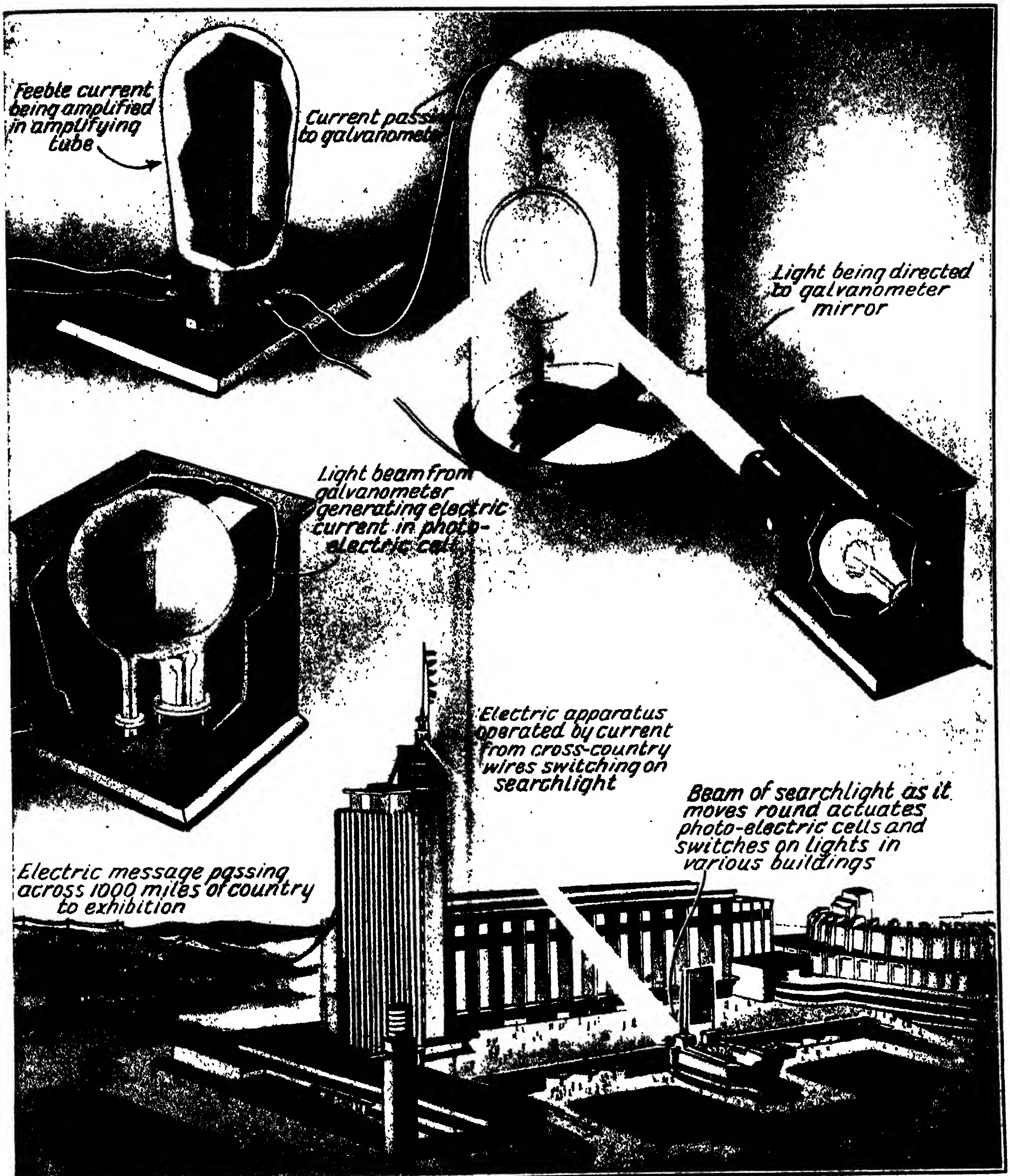
A general view of the great exhibition of 1933 at Chicago, with all its lights shining. These were first switched on by mechanism operated by a ray of light from the distant star Arcturus, the most rapidly moving star we know in the heavens

A GREAT MARVEL OF MODERN SCIENCE:



On these pages we see in simplified form one of the greatest achievements of modern science. About 120 years ago a ray of light started out on its vast journey through space from the bright star Arcturus in the constellation Bootes, which appears in the sky not far from the Plough. One day in March, 1933, this ray of light reached the Earth. It was caught by a great telescope at Harvard College Observatory in Massachusetts, and being reflected from the large mirror at the end to a small mirror at the top was again reflected, so as to strike upon a photo-electric cell. In this cell the light from the star set up a faint current of electricity which was passed through an amplifier and strengthened. From the amplifier the current passed to a galvanometer in which a mirror caught a light focused upon it from a lamp. The current caused the galvanometer mirror to turn and reflect the light upon a second photo-electric cell, where a rather stronger current was set up by the light. This current was passed through a second amplifier where it became strong enough to work a telegraph instrument which sent a message over the telegraph wires for a thousand miles to Chicago, where

HARNESSING A STAR'S LIGHT FOR WORK



an exhibition was about to open. By means of a relay, the electric message switched on a searchlight on the exhibition tower and turned the searchlight so that it shone upon the buildings in the exhibition grounds. As the light fell upon each building in turn it actuated a photo-electric cell and set up a current which switched on the lights in that building. Thus, in a short time, the whole of the exhibition was lighted up by the work done by a distant star's light. To make sure in case of cloudy weather in some districts, four observatories caught the light of Arcturus and passed it on as electricity to Chicago. Arcturus is about six hundred million million miles away. It is the most swiftly moving star that we know, having a speed of 257 miles a second, and it is approaching our Earth at the rate of about five miles a second. Its light is said to be 1,300 times as bright as that of our Sun. When the electric light that did the great work first left Arcturus most of the people in the civilised countries of the world were using candles to light their buildings. Queen Victoria had not yet come to the throne and both the Crimean War and the Indian Mutiny were still a long way in the future.

A MODERN TRAMCAR WITH SUNSHINE ROOF

Some people talk as though tramways were an obsolete form of transport. But while it is true that the tramcar confined to a railed track is an unsuitable form of vehicle for very narrow and crowded streets in large towns, it is still regarded as a very useful and convenient form of transport where the conditions do not render the inflexible track inconvenient. The improvements in tramcars have been as great in recent years as those in motor-buses, and in this picture we see a type of luxury tramcar in use in Blackpool. It has a streamline body, a sunshine roof, an electrical heating apparatus for use in winter, doors at the sides, and can travel forty miles an hour

THE GREAT SHIELD USED FOR TUNNELLING

The marvels of machinery are never more manifest than when a great tunnel has to be driven through a mountain or under a river or city. Then the great steel shield with various devices for excavation, and hydraulic rams for driving the shield forward, form together a remarkable illustration of how man has triumphed over Nature. Something of the wonders of the tunnelling shield is described below.

Men have tunnelled in the earth from very early times. King Hezekiah, we are told, bored through the rocks so as to bring water to Jerusalem, and the Greeks tunnelled to make a channel for the water supply of Athens. The Romans also were great tunnellers, and when we realise how little they had in the way of machinery we marvel at their achievements.

When Marc Isambard Brunel, the great French engineer, undertook to bore under the Thames and make a roadway between the north and south sides of the river, he invented a great iron shield divided into compartments, in each of which a man could work digging out the earth.

As the digging proceeded the shield was moved forward while bricklayers behind cased round the tunnel with brickwork so as to make it strong and waterproof. Brunel had got his idea of the shield and the bricking round of the tunnel as the work proceeded from the teredo, or ship's worm, which bores its way through the timbers of wooden ships and lines its tunnel as it goes with a chalky casing

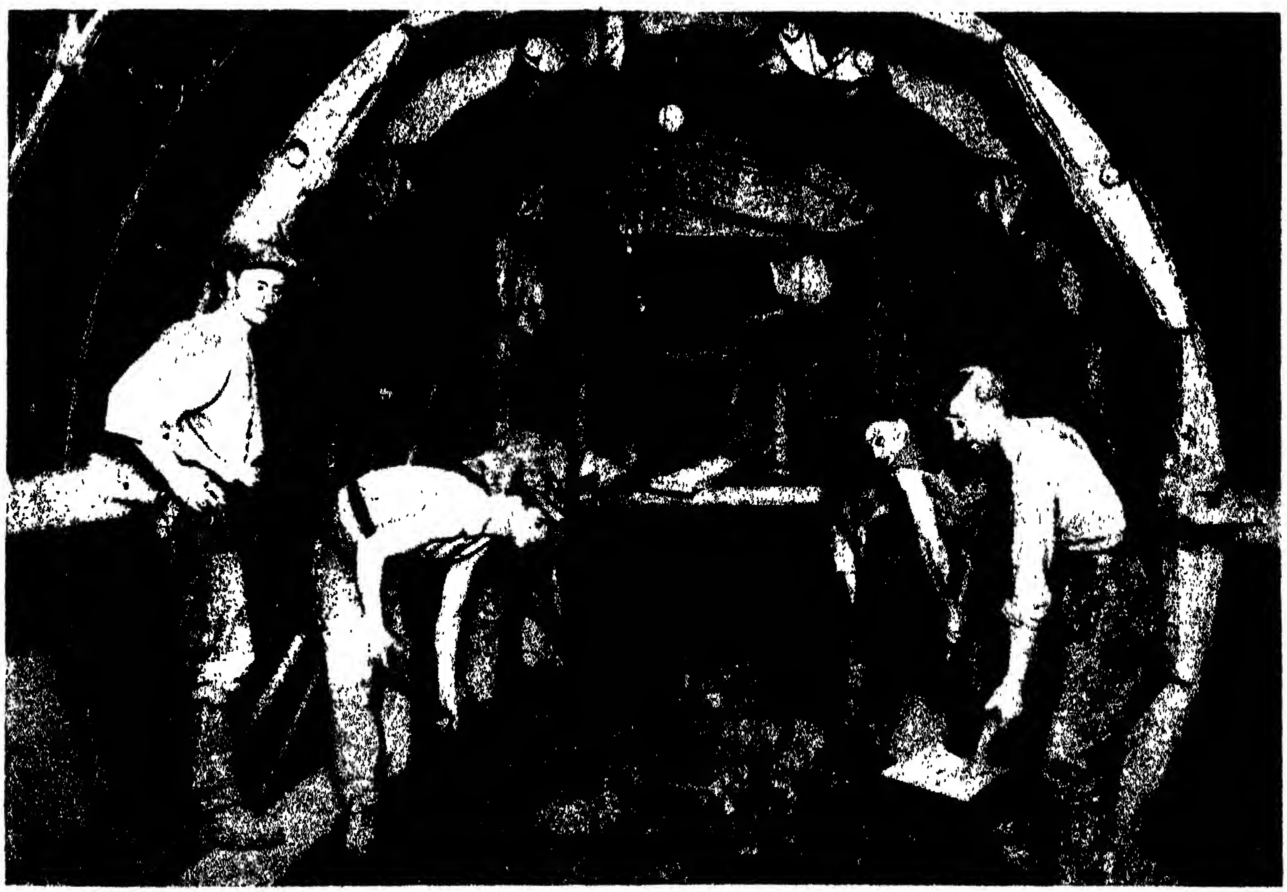
Brunel's shield was a great success and he constructed the very first tunnel under a river.

Since those early days of the nineteenth century the tunnelling shield has been enormously improved. It takes different forms, according to the material through which it is to be forced.

When, for instance, as in the case of most of the London tube railways, the boring is to be done through clay which holds no water, the tunnel has a cutting apparatus in front which cuts away the clay as the shield is forced forward by hydraulic rams.

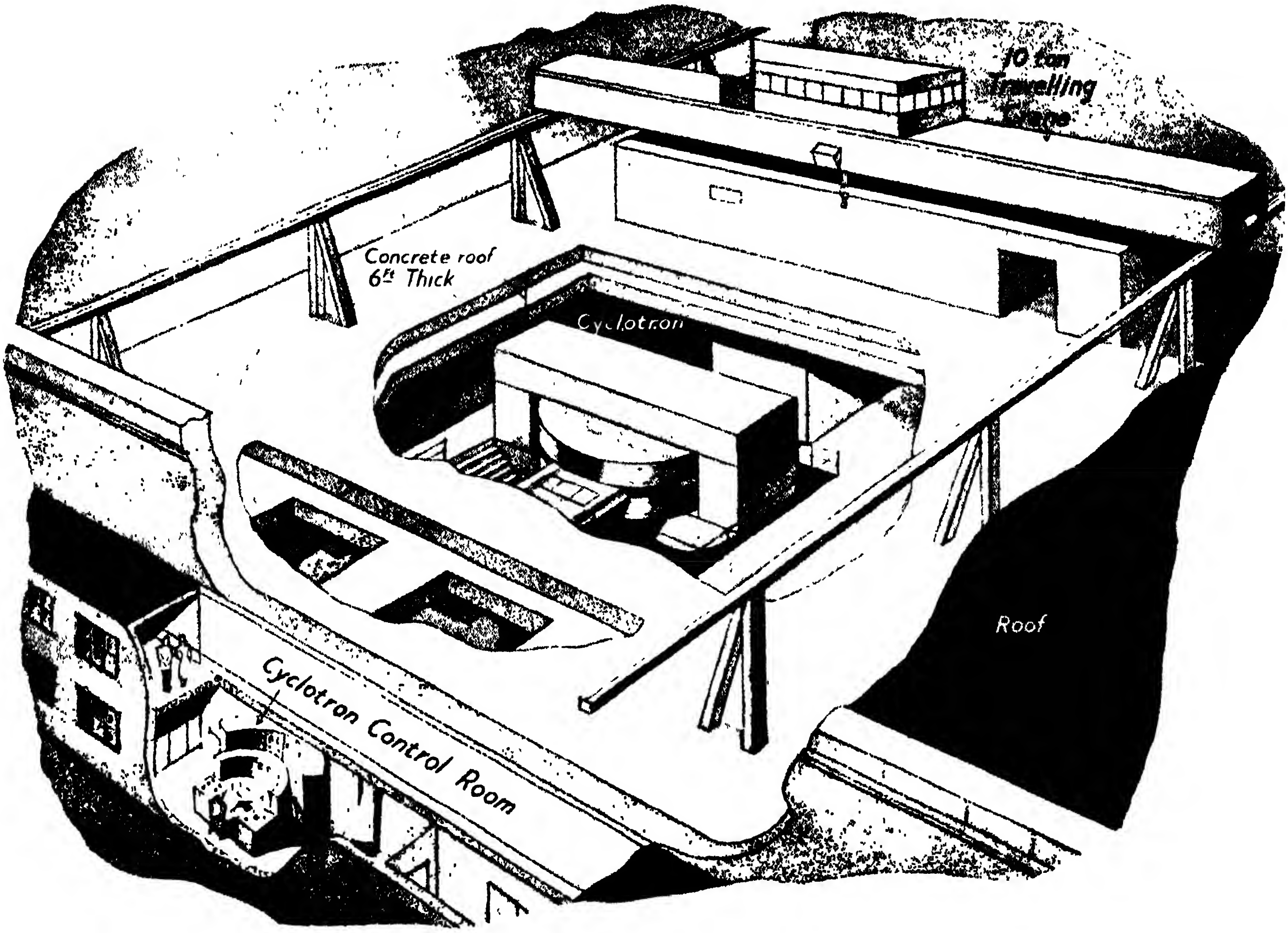
When the tunnelling is through such material as gravel or sand, which contains much water, so that there is danger of the water rushing in, the shield is in the form of a cylinder, which is filled with compressed air, so that the water does not enter. In some cases the air pressure is as much as 48 pounds to the square inch, or more than three times the ordinary pressure of the outside atmosphere.

The tunnel is usually begun at both ends, and so accurately do the tunnellers work that when the two sections meet in the middle they are practically in the same line. One tunnel, for instance, nearly a mile long when the two workings met, was only half an inch out of alignment, and the difference in level was only one-sixth of an inch. In another tunnel nearly five miles long, the errors were even less

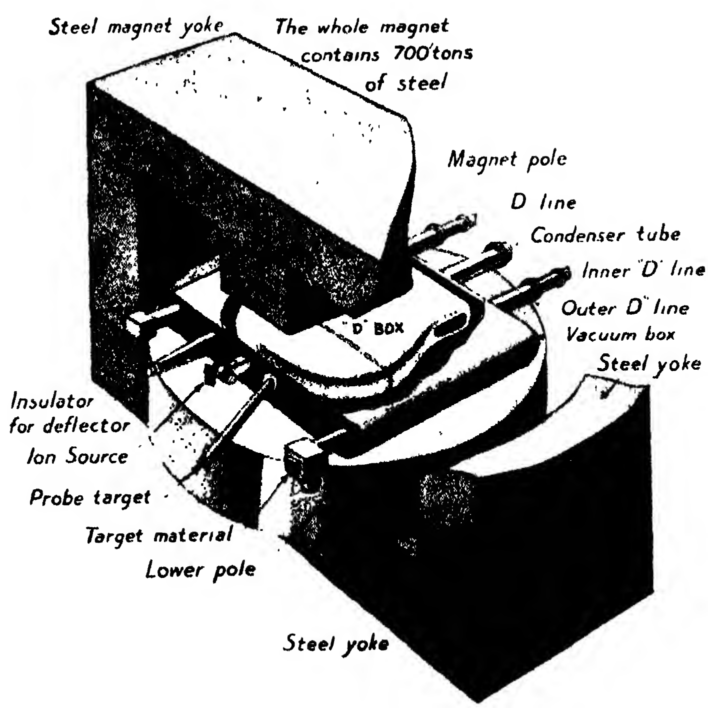


A modern type of head shield used in driving underground tunnels today. Where there is danger of water coming through the men work under great air pressure so that the pressure may keep the water out

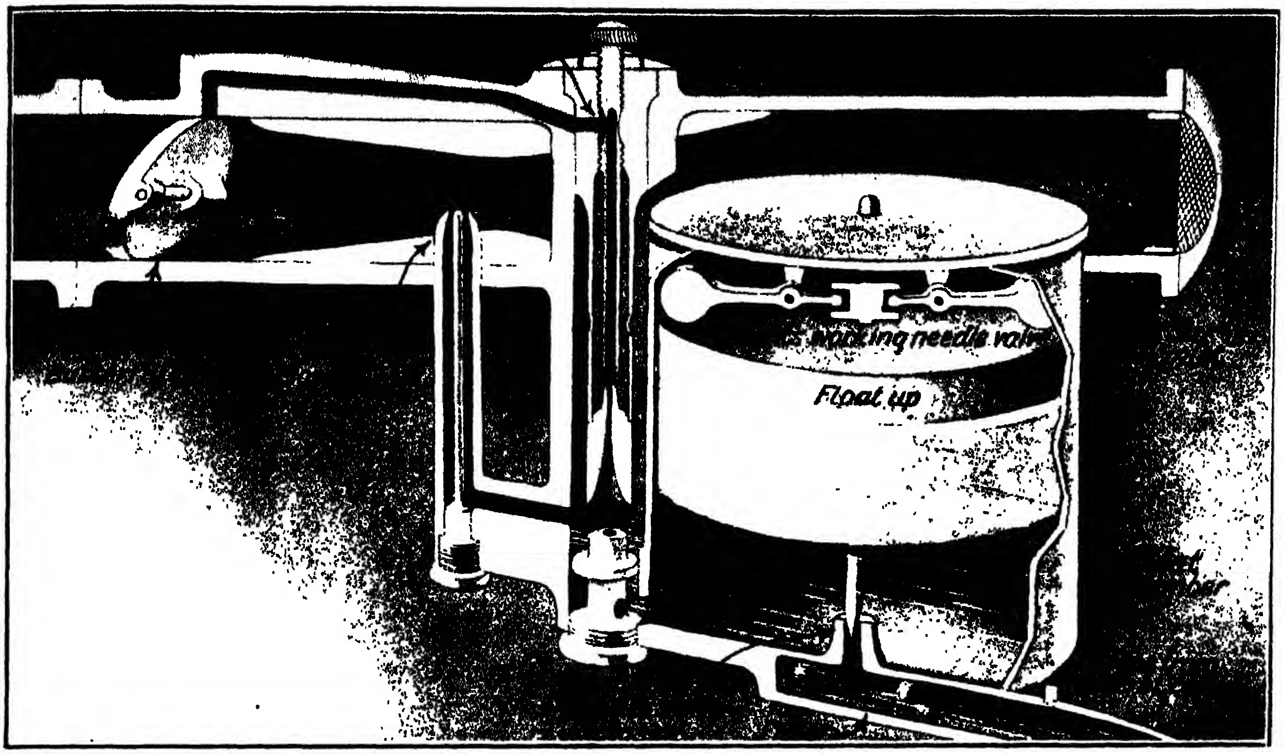
A MOVEMENT OF 95,000 MILES A SECOND



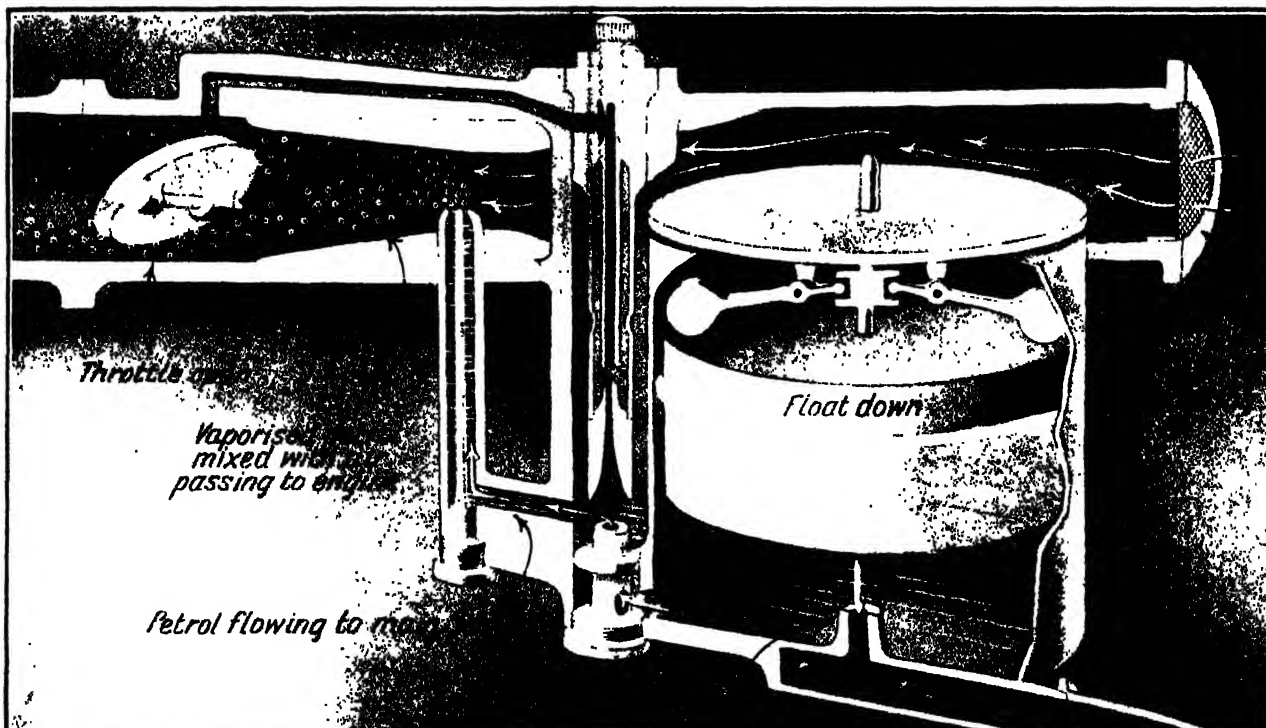
A cyclotron is an instrument used in atomic research to produce streams of high-speed atomic "bullets" to bombard a particular metal or element, and so split and change its atomic structure. These drawings of the cyclotron at the British Atomic Energy Research Station, Harwell, give you some idea of the vast size of the instrument. The particles or ions are produced by a discharge of electricity in a gas-filled chamber at the centre of the magnet gap. The particles then enter the "D" box, where the magnet causes them to move in a spiral path, their speed being increased by applying to them twice every revolution an accelerating current. During this acceleration, the particles travel thousands of miles a second and are then discharged at a speed of 95,000 miles a second against the target material. During their frantic rushing round, the particles emit dangerous radiation, and because of this the cyclotron is surrounded by thick concrete and is operated by remote control.



HOW THE CARBURETTER DOES ITS WORK



These pictures show how the carburetter of the motor-car works and supplies vaporised petrol mixed with air to the cylinders, so that this can be exploded to work the pistons. Here the car is at rest and nothing is happening. The petrol is shown in the float chamber with the float up, the two pivoted levers having pushed down a needle and closed the inlet from the petrol tank. The throttle is here shown closed and no air or petrol is entering the cylinders of the engine. The filter prevents dust and other substances from entering the jet



Here the opening of the throttle causes the engine to set up a suction, drawing in warmed air through the air inlet and petrol through the main jet. This jet forms a spray composed of minute liquid particles of petrol which, when mixed with the warm air, becomes a gas ready for explosion in the cylinder. As the petrol in the float chamber is used, the float tends to fall, carrying with it the weights of the pivoted levers, thereby raising the needle and opening the petrol inlet. The petrol can thus enter, so that the level in the float chamber remains the same. When the throttle is open only a little the petrol in much smaller quantities is drawn through a slow-running jet shown at the top of both pictures and marked in the upper picture. The mechanism in these drawings is simplified for clearness

MACHINERY AS A DOMINATING FORCE

Machinery is coming to be more and more the dominating force in modern life. We all depend upon the machine for the things we eat, and the things we wear, the journeys we make, and even the games we play.

Our homes are made by machinery, our food is prepared to a very large extent by machinery, our roads and public buildings, banks and churches, are erected by means of machinery, and it is difficult to find any department of life into which machinery does not enter.

Even the author uses machinery in producing his literary works, for instead of writing them with pen and ink, as did Sir Walter Scott and Charles Dickens and John Keats, he prints them by means of a very clever machine called a typewriter. Even when he corrects the proofs he uses another clever little machine called a fountain pen.

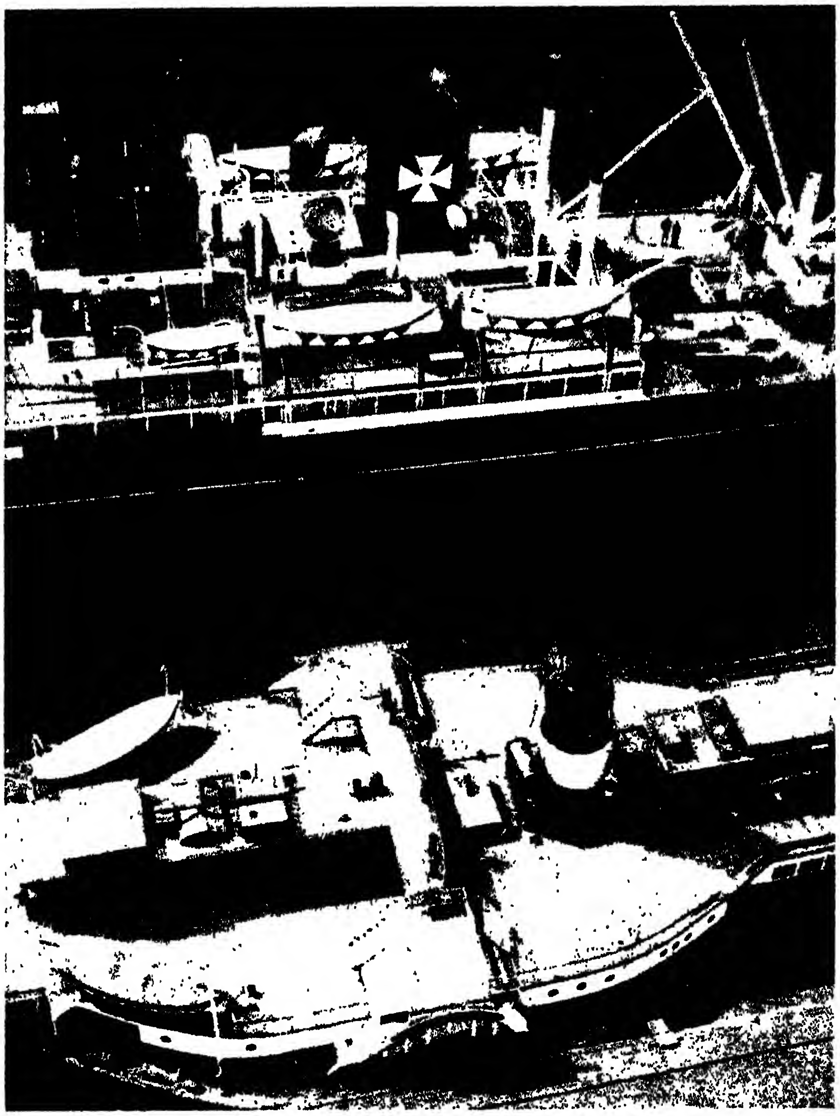
None of us can get away from the machine, to-day. If, in travelling, we decide that we will not ride in a machine, whether it be a train, or a motor-car, and set off walking on the roads, we have constantly to be looking out to see that a machine in the form of a car or lorry or motor-bus does not knock us over.

The character of the machinery that is used dominates the style of a factory building, the shape of a motor-bus or car, and the outline of a boat. Modern flour mills, for example, are tall buildings because the machinery of a flour mill is so constructed that it must be on several floors, the corn or flour as it is treated, first by one machine and then by another, passing by means of gravitation from the top floor to the next and then to a lower floor, being carried up again for another series of operations by means of elevators.

The form of a ship depends to a large extent upon the nature of the engines which drive it. In looking through a chart, for example, that shows the comparative sizes of the various types of mail steamers built for a great steamship company between 1840 and the present day, we shall notice that the vessels have not only increased in length but have changed considerably in form.

Up to 1862 they were paddle-steamers, and so had a very broad beam amidships. With the coming of the screw propeller at the end of the ship and the turbine engine the vessel did not thus have to be so broad in proportion to its length at the centre part.

A striking example of how the engine dominates the form of the ship is given in the photograph which appears on this page. We have a view looking down upon a screw steamer lying by the side of a paddle-steamer. The difference in the form amidships is very manifest, although paddle-steamers are still preferred for some ships, such as pleasure craft.



A striking photograph showing the difference in the shape amidships of a vessel that is driven by a screw propeller and one driven by paddle-wheels. Paddles are still used on some pleasure steamers as they give greater deck space and are very suitable for flat-bottomed ships using rivers and other shallow waters.

The domination exercised by the machine is shown equally on land where, owing to its invasion of transport, roads and bridges that have stood for hundreds of years and have been capable of carrying all the traffic that passed upon them, have had to be rebuilt in stronger form, in order to support the heavy vehicles that now use the roads.

The typewriter is making good handwriting a lost art. Even cheques are now filled-in in large establishments by an ingenious machine. No longer do clerks in banks add up long columns of figures till they become expert at the work. This is all done now mechanically by adding and calculating machines.

In the home the housewife beats up the eggs for cooking with a machine, sweeps her carpets with a machine, and if she does the washing at home carries this out also by means of electric machinery.

In the various trades the old skilled craftsmen are becoming a thing of the past. Few apprentices now learn to do such things as cabinet-making and boot-making by hand. Most of our furniture and our boots and our clothes are made by ingenious machinery, almost human in its operation.

On the farm the cows are milked by machinery, the chickens are hatched by machinery, the seed is sown and the crops harvested by machinery.

WHAT HAPPENS IN AN ELECTRIC CELL

There are many different kinds of electric cells, but all are on the same principle. They consist of two metal plates immersed in weak acid and the chemical action which results is transformed into electrical energy which can be conducted away by means of a copper wire. Sometimes a plate of carbon is used in place of one of the metals. Here we read something about electric cells and batteries

WHAT is Electricity? Nobody can say except that it is a form of energy, and the latest discoveries of scientists suggest that it is really the basis of all matter; or, in other words, that the atoms of which all substances consist are really made up of particles of electricity.

But although we cannot fully understand the real nature of electricity, we can all make use of it in a variety of ways, and few homes in Great Britain to-day fail to use electricity in some form or other. If we do not have electric fires and electric-cookers and vacuum cleaners and telephones, at any rate we have electric light or wireless; and if we have none of these conveniences we probably use a portable flash-lamp, the light of which is provided by electricity.

When electricity is wanted on a large scale, as for driving a railway or lighting a city, it is produced by a generator driven by a steam or water turbine; but for various domestic purposes such as electric bells, wireless sets, and so on, we use batteries or accumulators, of which there are many different forms, suited to different purposes.

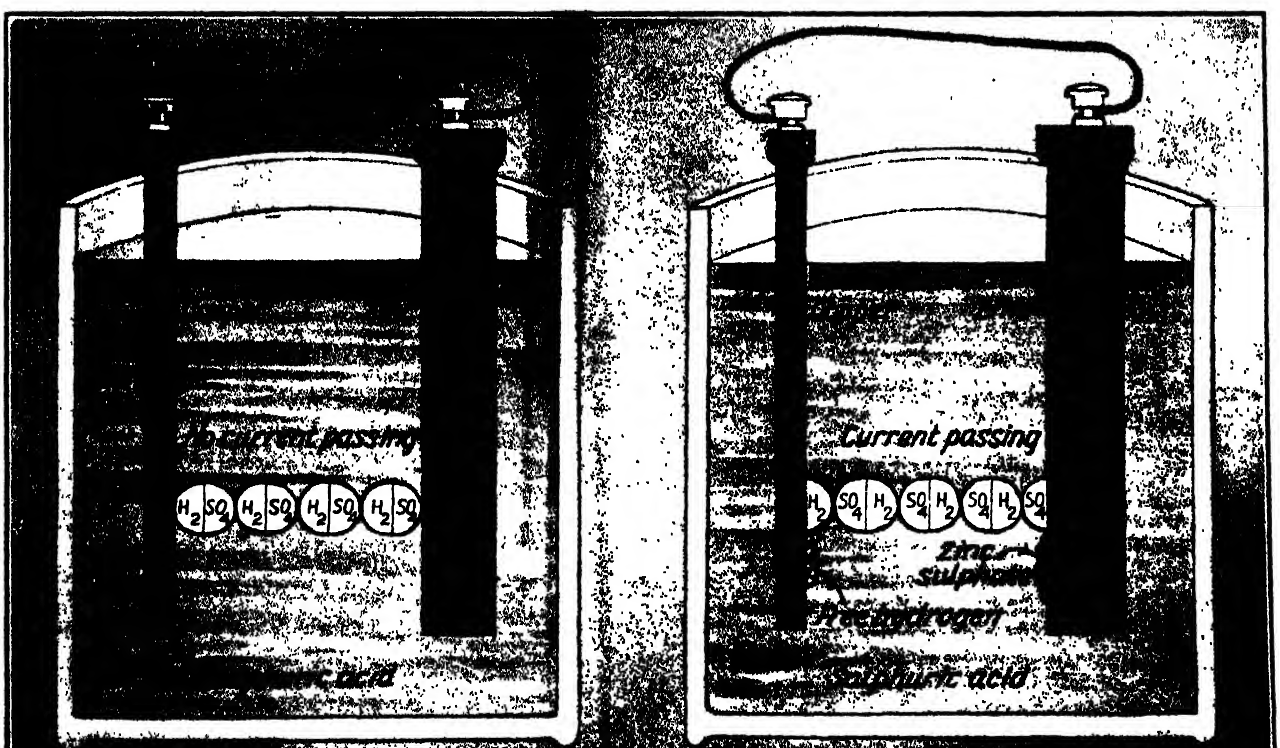
The battery method of producing electricity is too expensive for use on a large scale, and that is why we produce it mechanically at power stations. In a battery the electricity is produced by chemical action; in other words, chemical energy is changed into electrical energy just as by a generator at a power station mechanical energy is changed into electrical energy.

We speak of "generating" electricity, but, of course, this is not a strictly correct term. Electricity cannot be generated, for it already exists in the structure of all matter. What we do by means of a battery or generator is to rearrange the protons and electrons of the atoms, and cause them to move in certain directions.

A battery is made up of two or more electric cells, and some of the chief forms of cell are shown on the next page. The simplest cell consists of a vessel containing an acid which acts chemically on some metal immersed in it, the chemical action being transformed into electrical energy.

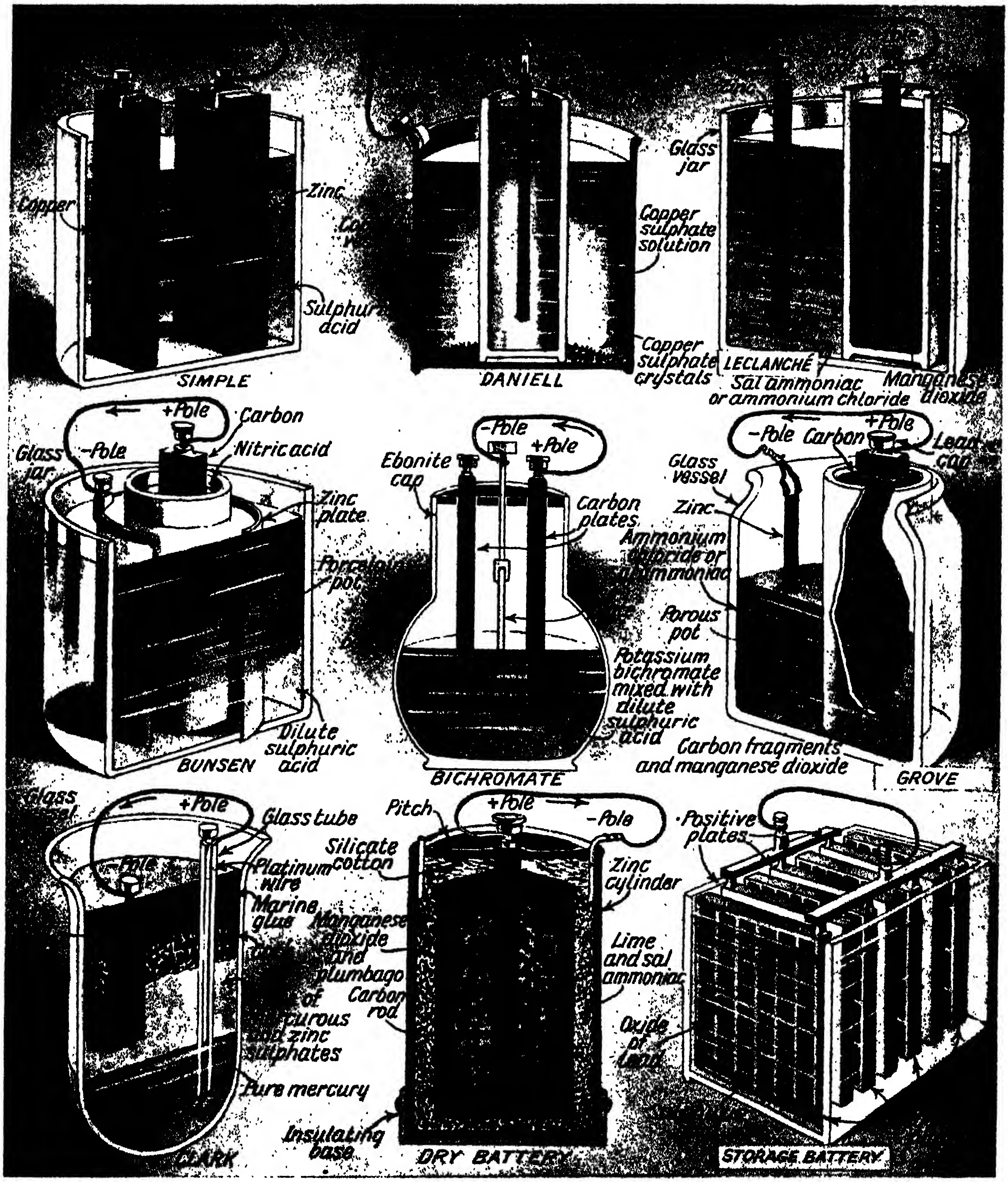
For example, if a plate of copper and another of zinc be placed in dilute sulphuric acid, the acid acts on the zinc plate, dissolving part of it and producing electrical energy equal to the amount of chemical energy expended. If the two plates be joined by a copper wire, forming what is called an electric circuit, the electricity will pass as a current along the wire. It is merely conducted or guided by the wire, and does not pass through it as water does through a pipe.

All electric cells are on this principle, though different substances are used



Here we see what goes on in an electric cell. In the first cell the wires are not joined up and so the circuit is broken. The molecules of sulphuric acid, therefore, remain unchanged. Each molecule consists of two atoms of hydrogen, represented as H_2, one of sulphur S, and four of oxygen, O_4. Directly the wires are joined and the circuit completed, as in the second cell, chemical action begins. An atom of zinc combines with the sulphur and oxygen atoms of the acid molecule forming zinc sulphate and freeing the atoms of hydrogen, which thereupon combine with the atoms of sulphur and oxygen in the next molecule, freeing that molecule's atoms of hydrogen. So the chemical action goes on till we come to the last molecule of acid in the series. Here there are no sulphur and oxygen atoms left to combine with the liberated hydrogen atoms, and so they collect on the copper plate

DIFFERENT KINDS OF ELECTRIC CELLS



An electric cell consists of two metals, or one metal and carbon, immersed in a liquid which acts chemically on one of the metals, the chemical action being transformed into electric energy. There are many different kinds of cell, adapted to different purposes. Here we see some of the more familiar cells used in general practice, with the substances of which they are composed and the positive and negative poles marked. The zinc is always the negative pole and the electric current flows through the copper wire from the positive to the negative pole. Some scientists, however, now say the flow is in the opposite direction. Different-shaped vessels are used for these cells. In a storage battery (accumulator) there are two sets of lead plates in sulphuric acid. One set is partially transformed into lead peroxide by passing an electric current through the cell. So long as the plates differ, the storage battery acts as a cell and will supply a current. When it is run down by passing a current through it, one of the sets of plates will again be reduced to lead, and the other set oxydised to lead peroxide. Then the storage battery will again act as an electric cell.

SOME EASY ELECTRICAL EXPERIMENTS

One of the great things about electricity is its attractive and repulsive power. There are two kinds of electricity, which we call positive and negative, and anything charged with

A tumbler attracts a feather

positive electricity will repel anything which is also charged with the same kind of electricity, whereas a positively charged object will attract another object that is charged with negative electricity, and vice versa.

A number of easy experiments will make this clear. First let us generate electricity by means of friction and prove that although nothing is to be seen yet something has happened. We take a flower vase or a glass tumbler, warm it and rub it with a piece of dry silk. If we bring a feather towards it we shall find that the feather is attracted to the glass.

Now let us cut out of tissue paper two butterflies. Suspend one by a silk thread from a glass rod. Take a vulcanite rod—a fountain-pen will do—and rub it with a piece of dry wool or flannel. The vulcanite

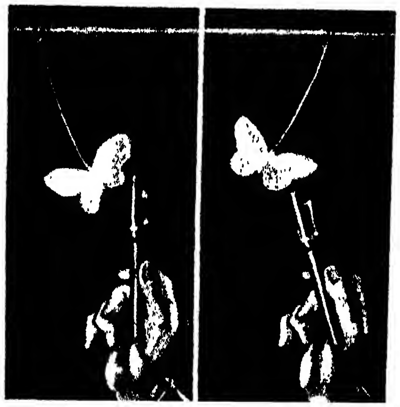
The paper butterflies which repel and attract one another

by the friction has become charged with negative electricity. We hold the pen near one of the paper butterflies, and it is at once attracted, but after a time it parts from the vulcanite rod and as we bring this nearer the butterfly recedes. What is the reason? The fact is that the paper butterfly was first attracted by the electrically charged rod, but when some of the negative electricity had passed to the paper, both being negatively changed, repelled one another.

We can carry out the same experiment, using instead of a vulcanite rod and the wool, a glass rod and a piece of silk. We rub the glass with the silk, when it becomes positively charged.

Now let us electrify the paper butterfly with the vulcanite rod, and immediately afterwards bring the glass rod to the butterfly. At once the positively charged glass rod attracts the negatively charged butterfly, and holds it.

We can try another experiment of a



Strange behaviour of a paper butterfly when touched with a fountain-pen

similar kind. Hang two butterflies up on the glass rod about an inch from one another. Electrify both with the glass rod, and they fly apart. Later electrify both with the vulcanite rod and they fly apart, but electrify one positively with the glass rod and the other negatively with the vulcanite rod, and they attract one another.

Here is an interesting experiment of a more elaborate kind. Take a lacquered tray about a foot long. Cut out a sheet of thick brown paper which will cover the level portion, and stick two bands of paper one at each end of the brown paper for handles.

Now stand the tea tray on glass tumblers to insulate it. Warm the brown paper, and laying it on a wooden table, rub briskly with a hard clothes brush or woollen cloth. Then place it on the tray

A spark from a tea-tray

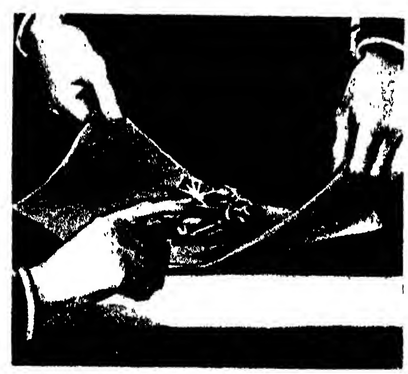
by the handles. After a minute or two raise it up and let somebody bring his knuckle or finger-tip to the corner of the tray. A spark will be seen. It is the electricity passing from the charged tray to the knuckle, just as a flash of lightning passes from one cloud to another, or from a cloud to the Earth.

Carry out the experiment once more,

A home-made electrophorus

and instead of putting a knuckle to the tray, place the handle of a spoon which has been stood in a dry glass tumbler three-quarters full of small shot. After a time take the tumbler away and, holding it on one hand, bring the knuckle or finger-tip to the handle of the spoon. There will be a crack and a spark. The electricity of the tray has been collected by the spoon in the tumbler containing shot, which thus forms a home-made electrophorus.

One more interesting experiment with electricity is the following: Take a sheet of drawing paper or brown paper and lay it on a wooden table. Rub it with a clothes brush or woollen cloth. Now place a small bunch of keys in the centre and raise the paper by two corners. If someone presents his finger to the keys a



A spark obtained from a bunch of keys held in a sheet of paper

bright spark will flash from the key to the finger.

All these experiments are best tried in dry weather and it is also important that the materials we use should be perfectly dry. If they are at all damp the experiments will not succeed so well, and perhaps they may be altogether a failure. With care, however, we shall find that the experiments are quite easily performed by any boy or girl

WHY WE KNOW A POUND WEIGHT WEIGHS A POUND

When we buy a pound of apples how do we know that we are actually receiving a pound? Well, we see the tradesman take a weight which is marked "1 pound" and put it in one pan of the scales, and the apples in the other pan, and if the two pans balance we believe that we have really received a pound of fruit.

But how do we know that the weight marked "1 pound" actually weighed a pound? To some extent we trust the tradesman, and to some extent the inspector of weights and measures, who we know goes round the streets from time to time and may call at the tradesman's shop and test his weights with other weights which the inspector himself possesses.

This, however, only pushes our inquiry back a stage farther. What reason is there for believing that the inspector's weights are actually correct? Well, this brings us to a long story.

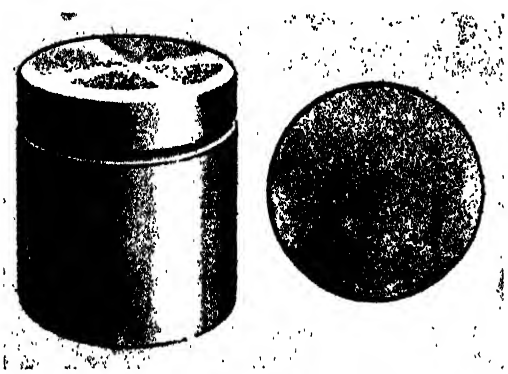
There exists what is known as the British Standard Pound, and anybody who sells goods by weight in Great Britain must see to it that his pound weight corresponds with the weight of this Standard Pound. The pound in England has not always been the same weight.

At different times there have been five different kinds of pounds. There has been the pound of 12 troy ounces, or 5,760 troy grains; the pound of 11¼ troy ounces, or 5,400 troy grains; the pound of 15 troy ounces, or 7,200 troy grains; the pound of 16 troy ounces, or 7,680 troy grains; and finally the pound which we use to-day, and which is compulsory upon everybody who sells goods, namely the pound of 16 avoirdupois ounces.

The first of these was the original British pound, and it was based on the Roman pound, introduced by the Romans during their occupation of these islands. This is called the "troy pound," and the name is said to come from Troyes in France. The troy pound was used for weighing certain goods right down to 1878, when by the Weights and Measures Act of that year it was abolished.

The troy ounce, which was the twelfth part of a troy pound, has never altered, and consists of 20 pennyweights. At the present time the pennyweight is divided into 24 grains, but up to the reign of Queen Elizabeth it was divided into 32 grains. The grains in these two cases, however, were not the same.

In the early days, before men had decided upon a regular system of weights and measures, they used various natural objects for measuring quantity and size. For instance, they used the human foot and the human palm as measures of length, and they used grains of wheat and grains of barley as measures of weight.



The British Standard Pound made of platinum drawn to the exact size. On the left it is shown in perspective and on the right we see the base

The wheat grain weighed less than the barley grain, for 32 wheat grains balanced 24 barley grains. When therefore up to Queen Elizabeth's reign the pennyweight was divided into 32 grains, they were wheat grains, but since that time, with the troy ounce divided into 24 grains, barley grains are implied.

The word "pennyweight" was used because the silver penny coined at the mint was equal in weight to 32 grains of wheat taken from the middle of the ear, or, as in later days, equal to 24 barley grains.

The second pound of 11¼ troy ounces was the pound used for coinage. The third pound of 15 ounces was used in weighing heavy goods, and ceased to be a legal weight in Queen Elizabeth's reign. The fourth pound of 16 troy ounces was also used for weighing heavy goods. It ceased to be a legal weight in the reign of Queen Elizabeth. The fifth pound composed of 16 avoirdupois ounces was made legal by Queen Elizabeth as the standard avoirdupois pound, although it had been used for some time previously. Avoirdupois means "to have weight" and was a term used for heavy goods.

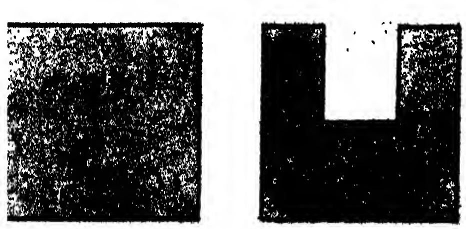
This pound was not divided into grains, but it was nearly equal to 7,000 troy grains. In 1824 its weight was slightly altered so as to make it exactly equal to 7,000 grains, and since 1878 it has been the only British pound which may be used. For weighing precious metals troy ounces are allowed and for drugs apothecaries' measure is based on the avoirdupois pound.

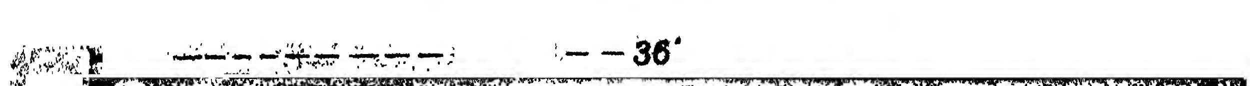
Now we come back to the question: How does the tradesman know that he is using the right weight? Well, there is kept in the Standards Department of the Board of Trade at Westminster a piece of platinum of which a picture is given on this page. This weighs exactly a pound, or 7,000 grains, and it is known as the British Standard Pound. It is very carefully guarded.

In four other places, the Houses of Parliament, Greenwich Observatory, the Royal Mint and the Royal Society, what are known as Parliamentary copies of this Standard Pound are preserved, and three of these are tested and compared with one another every ten years. That in the Houses of Parliament, however, is tested only once in twenty years.

Then other exact copies are supplied to many towns, and it is by means of these that the weights which are made for the use of the tradesman are tested.

Just as there is a Standard Pound for weighing things, so there is a Standard Yard for measuring things which is preserved in just the same way with the pound. This standard is a solid square bar of bronze having a section of a square inch.





A reduced drawing showing the British Standard Yard, which is a bar of bronze with a section of a square inch. The bar is 38 inches long, and the Standard Yard of 36 inches is the distance between the centres of two gold plugs let into wells at each end. Above is the section of the Standard Yard, actual size, and on the right the section where the well is sunk half-way down

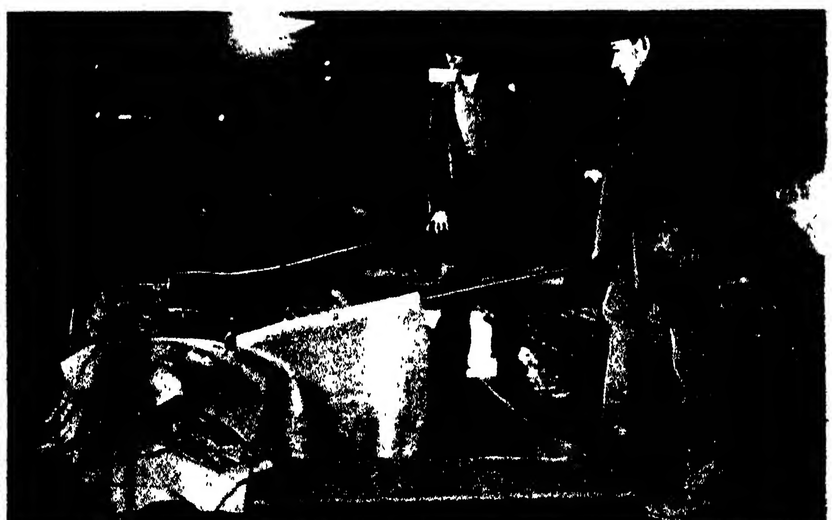
MAKING LEATHER FROM THE SKINS OF ANIMALS

Skins of sheep, cattle and other animals arrive at the tannery salted to preserve them. They are first of all soaked in water to remove the salt and dirt

Then they are placed in a drum fitted inside with pegs. The drum is revolved and the skins become pliable

To loosen the hair still on the skin it is treated with a solution of lime and is then ready for the next stage

Softened by the lime, the hair is scraped off with a knife, leaving the skin ready for tanning



Any odd pieces of flesh or fat are now removed and the skins are washed clean of lime. Then they are steeped in pits of a chemical called tannin made from bark

Tanning turns the skins into leather. This is now shaved to an even thickness, dyed, softened in oil and then goes to the staking machines, seen here, which stretch and soften it

Here women workers are treating the leather with a seasoning mixture and it is finally glazed, that is, rubbed with a glass or agate cylinder to give it an attractive shine

FIGHTING JACK FROST IN THE ORCHARDS

California is an ideal country for fruit-growing, and some of the finest grapes, apples, pears, figs, dates and oranges in the world are produced in that state. But occasionally the weather becomes less warm than normal and at night there is a frost, very slight, but sufficient to ruin thousands of pounds' worth of fruit crops. The orchard keepers, however, have learnt how to fight Jack Frost, and they do it in the manner shown in this photograph. They place at intervals in the avenues between the trees vessels containing oil with burners attached, and directly the thermometer shows that the danger point for the fruit has been reached they light the flares, which produce a sufficient warmth to overcome the frost. The wind disperses the heat so that all the trees are reached. The oil used is a cheap crude oil and the apparatus in which it is burned is inexpensive. Sometimes it consists of a round iron pan as in the photograph, and sometimes there is a square tank with a pipe leading the oil to a burner over which is placed a smoke stack

THE TERRACES THAT DISAPPEARED

We read of the everlasting hills and the mountains that cannot be moved, but the natural features of the Earth can always be upheaved and destroyed by an earthquake or volcanic explosion. One of the most striking examples of the changing of a landscape was the destruction of the Pink and White Terraces at Rotorua, in the North Island of New Zealand, the stirring story of which is told here

Some of the most beautiful natural scenery in the world is to be seen in the North Island of New Zealand. But the greatest glory of that country, the Pink and White Terraces, which were described as "the most remarkable of all spots of the earth," disappeared suddenly in a night.

The White Terraces consisted of a mass of silica rising like a great fan-shaped flight of alabaster steps to a geyser at the top. The continual trickling of silicated water had formed step after step of this remarkable formation, the silica being deposited as the water evaporated, thus forming a series of basins in which the beautiful blue water glistened. It was truly said that the White Terraces looked "as if a cascade rushing over space had been suddenly arrested and turned into stone."

The Pink Terraces were almost as beautiful, in this case the sapphire pools lying in terraced basins with a background of dainty roseate rock. These terraces were the glory of the Southern Hemisphere. Then something happened. About midnight on June 10th, 1886, there was a sharp earthquake, and an hour and a quarter later a big explosion on Mount Tarawera, an old volcano. Half an hour later a great eruption broke out from the summit of the volcano, a fissure opened across the mountain, and red-hot masses of rock were hurled into the air to a height, it is said, of eight miles.

Then there was a great explosion at the side of Lake Rotomahana, and a huge column of black cloud was hurled up, the earth for miles being violently shaken. Volcanic dust and ashes fell upon the village close by and crushed the houses, killing many of the inhabitants.

By half-past five in the morning the eruption was over, and the last earthquake shock was felt half an hour later. It was some weeks before the region of the Pink and White Terraces could be examined, for steam was ejected from the earth in such quantities as to make it impossible to go near. When at last a visit could be made it was found that Lake Rotomahana had disappeared and there was a chasm 515 feet deep on its site.

But where were the Pink and White Terraces? They were nowhere to be found. The explosion had blown them into fragments and strewn the rock of which they were formed all over the district. The whole area had become a dreary region of volcanic ash and craters. Later, the basin that had been formed by the explosion under Lake Rotomahana gradually filled up with water till there was a much deeper lake than formerly.

In recent years it has been suggested that the Pink and White Terraces were never destroyed, but only submerged by this lake, and there have been proposals to drain the lake and uncover the terraces. There seems, however, little justification for such a hope.

These beautiful White Terraces of Rotorua in the wonderland of New Zealand were made of glistening white silica displaying iridescent colours. Together with the adjacent Pink Terraces, they were blown up and destroyed in a single night by a great volcanic eruption

MAKING A MOULD THAT CURES DISEASES

MOST of us think of mould as an unpleasant furry substance that grows on stale bread and cheese But to-day one of the most effective substances used by doctors comes from a mould.

For some years Professor Alexander Fleming, who later became Sir Alexander Fleming, had been experimenting in his laboratory at St. Mary's Hospital, London, to try to find something that would destroy staphylococcus, which is the scientific name for the germ that has a lot to do with causing boils. One day in 1928 he placed on one side a dish of gelatin containing a large number of the germs; and promptly forgot about it.

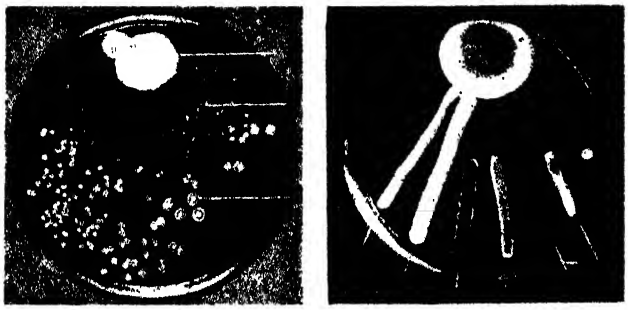
Two or three weeks later, Professor Fleming needed a dish for his work and the first that came to hand was that filled with the gelatin and staphylococcus. He was about to clean the dish out when he noticed a mould growing along one side.

Most bacteriologists would have been very annoyed to find mouldy gelatin in their laboratories and would have thrown it away. But Professor Fleming happened to examine the gelatin a little closer and to his surprise found that the staphylococcus were disappearing near the mould.

Professor Fleming now became very interested indeed and decided on another experiment. He collected some of the mould and placed it in a kind of broth which had the effect of making it multiply. When the broth was tested it was found to contain a substance which had the property of stopping the growth of the bacteria which cause a number of diseases.

Further experiments proved that penicillin destroys certain bacteria outright, some it dissolves, and others it prevents from increasing. A curious fact is that penicillin only destroys healthy and active bacteria and has little effect on comatose or weak bacteria; consequently, penicillin is most effective against serious infections.

Amongst the many diseases against which penicillin is of the greatest value are blood poisoning, pneumonia, meningitis, anthrax, and diphtheria. It can be given to a patient in any form, except by the mouth; the gastric juices in the body destroy its effectiveness if it is swallowed.



These two photographs, taken by a camera attached to the eyepiece of a microscope, show you what Professor Fleming saw when he began experimenting with penicillin. On the left, some penicillin, A, has begun to destroy germs, B, responsible for boils; the white spots, C, are gems which have not been affected by the penicillin. On the right are various kinds of bacteria as seen through a microscope; 1 and 2, boil germs, 3, diphtheria; 4, anthrax; 5, typhoid; 6, colic. The large white blob at the top of the circle is penicillin.

At first penicillin was very difficult and expensive to produce and its use was limited. But early in the 1939–45 war penicillin proved so successful in the treatment of wounds that its manufacture was begun on a large scale.

Early penicillin manufacture was very primitive, and in small quantities. Today penicillin is made in huge factories, one of which can produce 40,000 million doses a year.

The liquid on which the penicillin best thrives is obtained by steeping corn in huge tanks each holding 12,000 gallons of liquid. Penicillin mould is then "sown" in the tanks and milk sugar added to speed up its growth. Under the old system of using dishes, the mould grew only on the surface of the liquid, but in the tank method the mould grows throughout the liquid During the growing period, the temperature of the liquid must be carefully controlled.

In due course, growth ceases, and the liquid from the tank is passed through a series of filters until from the original 12,000 gallons only 15 remain; but the 15 gallons of liquid are pure penicillin. The liquid is then dried and yields five pounds of yellow penicillin powder.

One of the most curious facts about penicillin is that although it destroys bacteria, it is itself very liable to be contaminated by certain bacteria always present in the atmosphere. Consequently, the penicillin powder must be handled and packed under the most hygienic conditions.

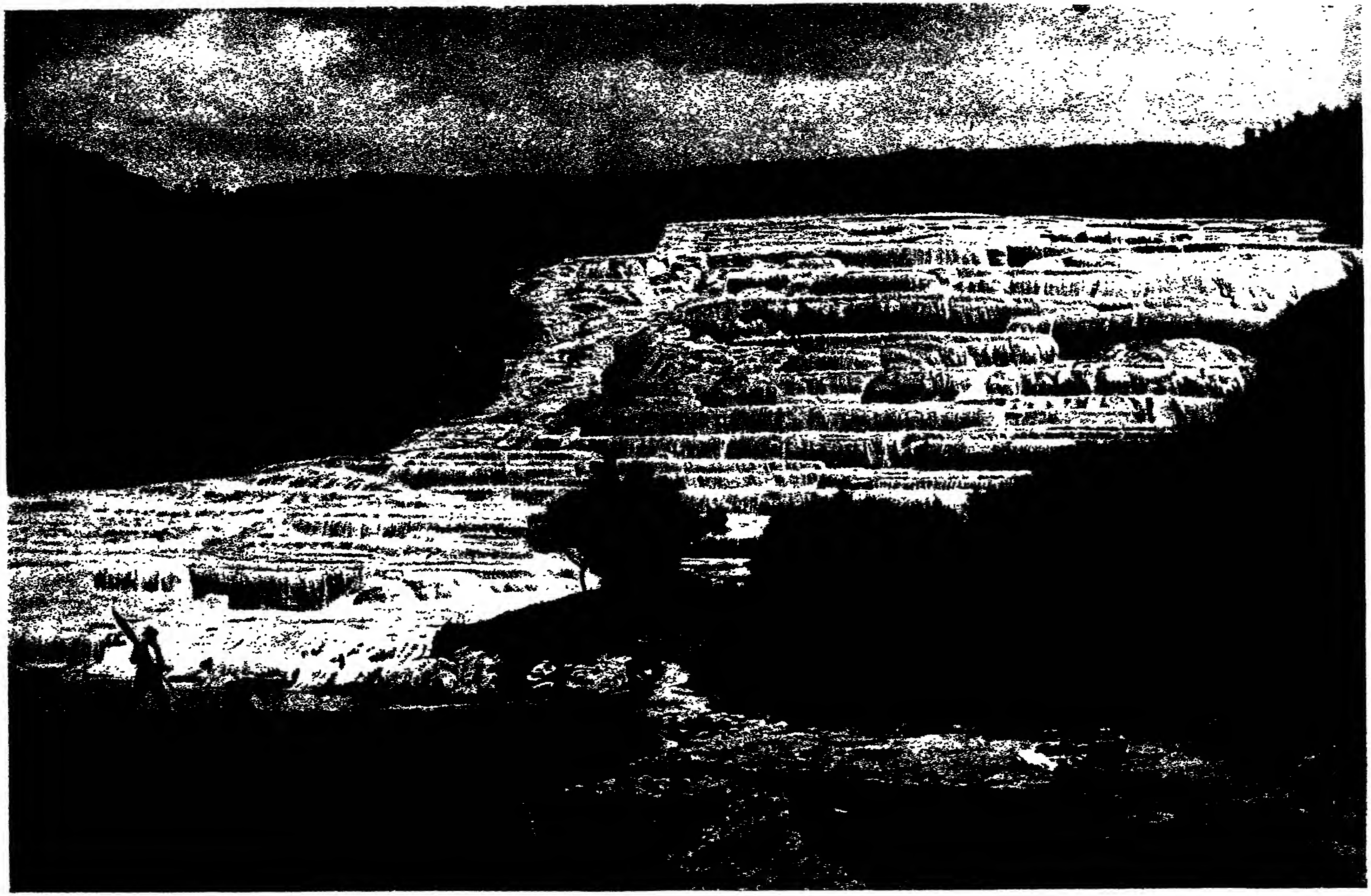
Persons entering the laboratories and packing rooms have to pass through a zone of ultra-violet rays, which have the property of killing bacteria. Next they change their outdoor clothes for sterilised gowns, gloves, and shoes, and put on sterilised masks.

Penicillin powder is packed in glass bottles, and from every batch of 100 bottles two are sent to the testing room There the penicillin is given to mice and rabbits, and its action on these animals is carefully observed to see whether it is safe for human use.

Some of the penicillin that passes all its tests for purity is sent to hospitals and doctors who use it directly in powdered or liquid form for the treatment of their patients. Penicillin is also supplied to manufacturing chemists for making into ointments and lotions.

Pure penicillin must be kept at an even, cold temperature, otherwise it loses much of its goodness.

Here you see two ways in which doctors give penicillin to a patient. The woman in the top photograph is suffering from throat trouble and is breathing through a mask containing penicillin. When penicillin has to be injected at regular intervals, the apparatus shown in the right-hand photograph is used. An electric clock automatically and at fixed times moves the piston of a pump forcing the penicillin through a hypodermic needle.

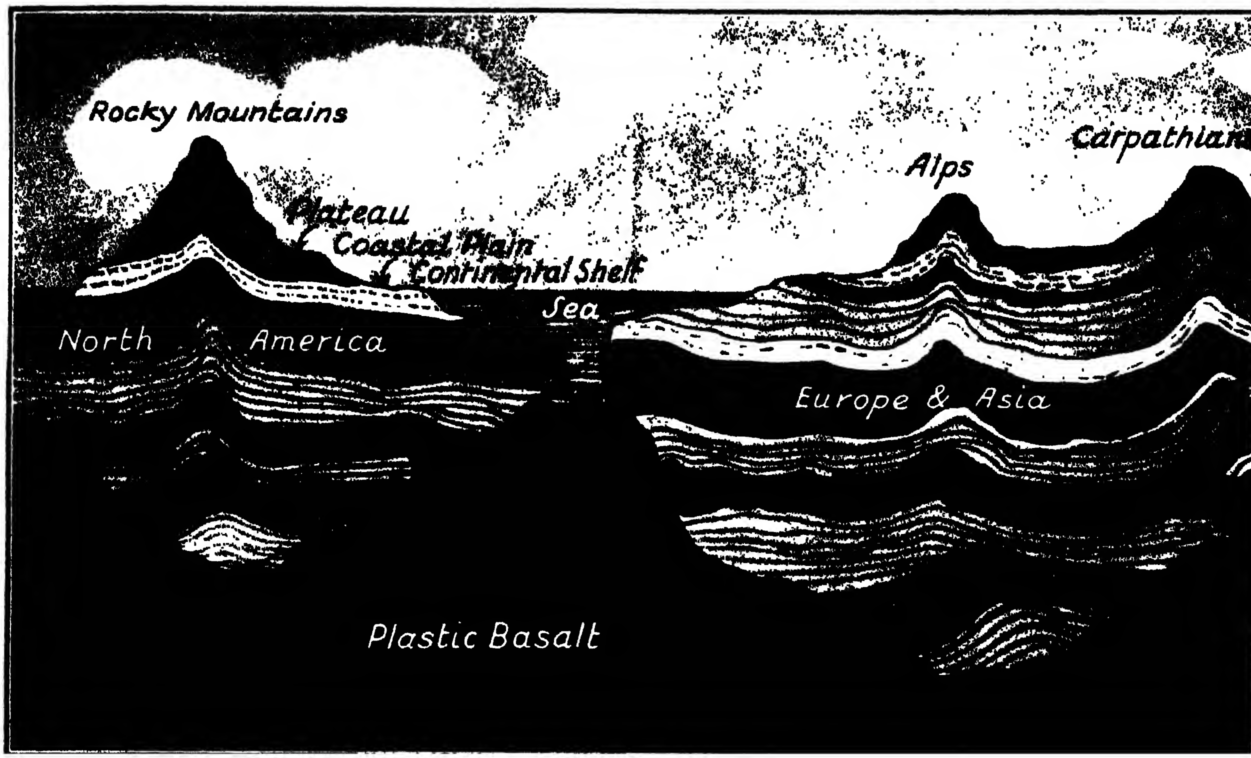


VANISHED WONDERLAND OF ROSY ROCK, ONCE NEW ZEALAND'S LOVELIEST BEAUTY SPOT

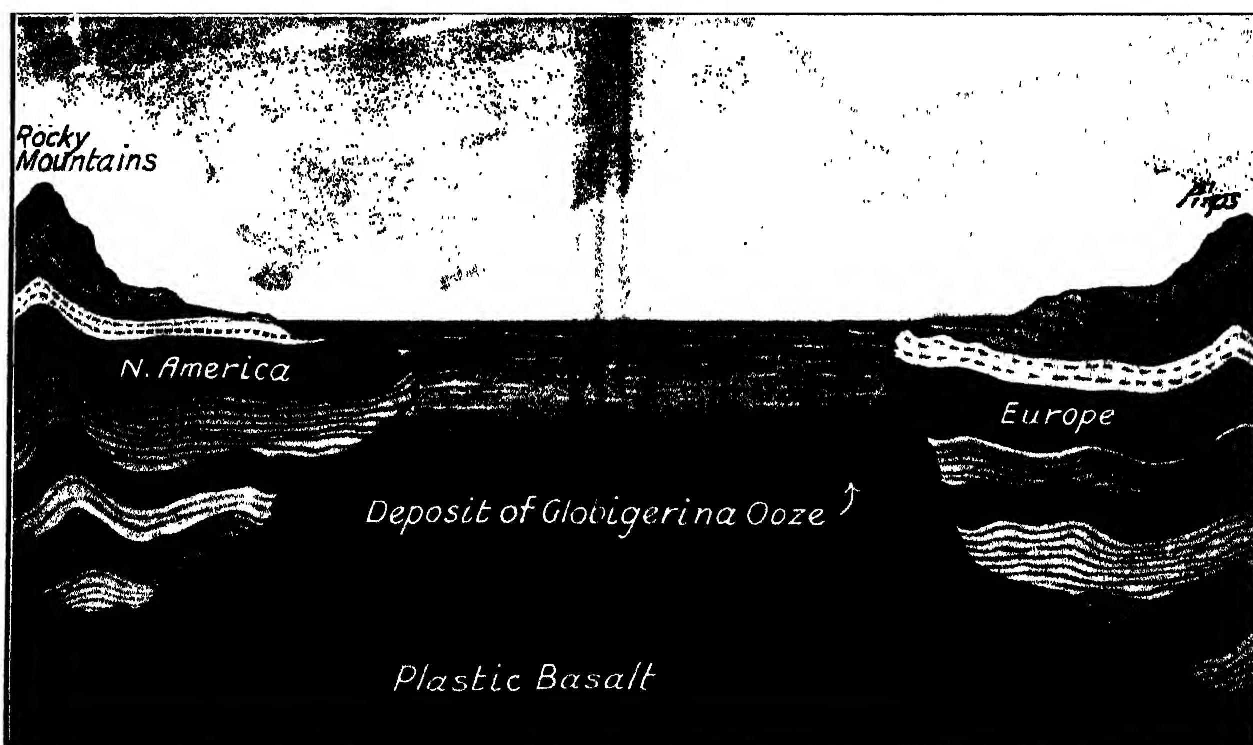
Before they were utterly destroyed in a great volcanic eruption in the night of June 10, 1886. the Pink Terraces of North Island. New Zealand, were, together with the White Terraces illustrated in page 1271, the glory of the southern hemisphere. On a sunny day this stairway of pink stone, coloured by a deposit in the silicated water which lay in sapphire-blue pools upon each glowing platform, was indescribably beautiful, contrasting its delicate hues with the green forest that grew beside it and the azure waters of the adjacent lake. But after one night of destruction and terror this lovely sight had gone for ever

To face page 1273

THE CONTINENTS FLOATING ON A SEA OF BASALT

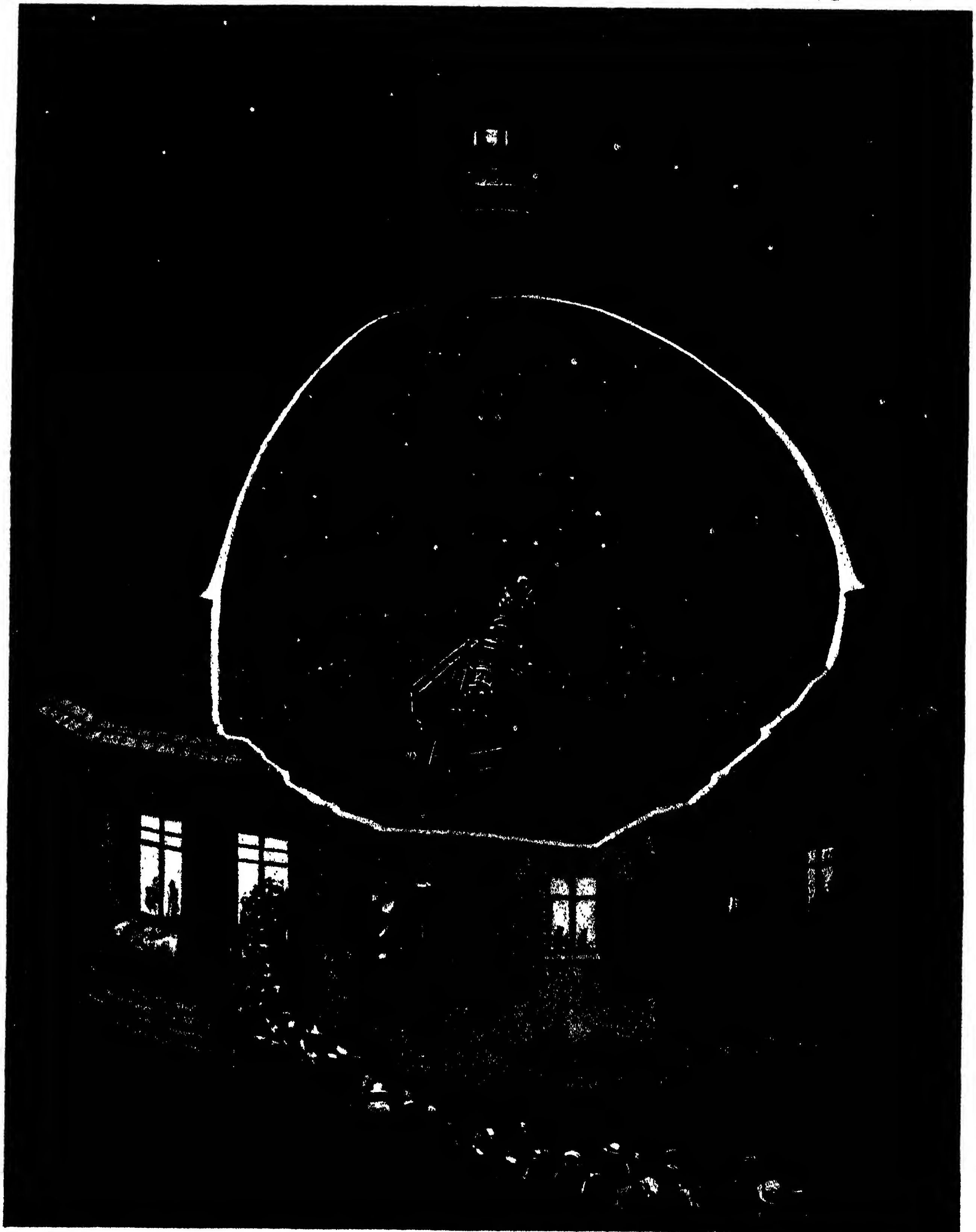


According to the theory of some scientists, the continents of the world are great masses of solid rock floating on a sea of liquid or plastic rock beneath the Earth's solid crust. Just as an iceberg floats in the sea with the great bulk of its mass below the surface, so, according to this theory, the land we see is only the top of a rocky iceberg floating, as it were, in a sea of basalt. This picture shows the idea in diagram form, and we see what are now the continents of North America and Europe when they were nearer together



In the course of ages, according to one theory, the floating continents drifted farther and farther apart, just as icebergs drift in the sea. By comparing this picture with the one above we see how America and Europe are supposed to have parted. On page 731 are three maps of the world showing three stages of this drifting of the continents. Just as an iceberg floats because it is of less specific gravity, that is less weight for a given volume than water, so these continents float on the basalt because they are of less specific gravity

WHAT A PLANETARIUM IS LIKE INSIDE



In Germany and America many big cities have what is known as a planetarium. It is a circular building with a dome, on the inside of which a wonderful projector throws points of light to represent the various stars in the sky. The projector, which is certainly one of the wonders of the world, is operated by clockwork and moves the points of light in the same way as the stars move in the sky. The movements can be speeded up or slowed down, and it is possible to see in an hour the movements of the stars and planets for a year

SPEEDING UP THE UNIVERSE

More and more people are becoming interested in the sky and the heavenly bodies, which form part of the great universe of which our Earth is but a very small member. Photographs and orreries are useful and interesting, but the most wonderful aid to the study of astronomy, after the observation of the heavens themselves, is the planetarium, which is described and pictured in these pages

Many of the large cities of Germany and America have a building known as a planetarium, and it is one of the most ingenious devices for popular education that have ever been invented. It consists of a building with a large domed ceiling, sometimes as large as ninety feet in diameter. Then a very complicated instrument, which is almost uncanny in its accurate working, throws upon the dome thousands of images representing the stars and planets.

The room is, of course, darkened, and by setting the apparatus at work the motions of the planets and other heavenly bodies are accurately shown on the dome. Two projectors throw an image of the Milky Way, and others print on the ceiling when necessary the names of the stars and their constellations in luminous letters.

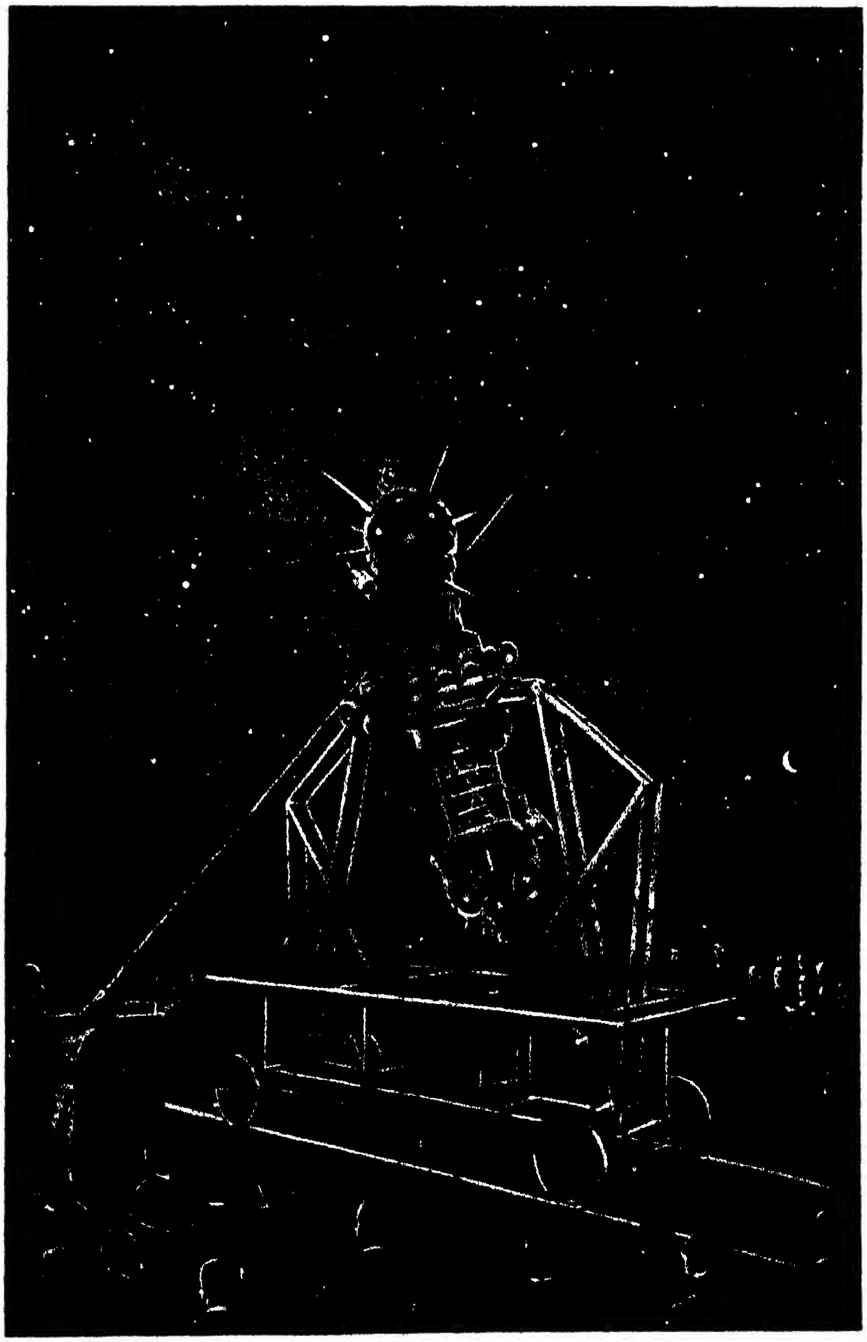
The great advantage of the planetarium is that not only can the rising and setting of the heavenly bodies be shown, but they can be speeded up or slowed down at will, so that what takes place in the heavens in 24 hours can be compressed into as short an interval as two or three minutes, and other motions which take a year can be run through in a few seconds.

Not only so, but the spectators who sit in the hall beneath the dome are able to see the heavenly bodies in the positions in which they were hundreds of thousands of years ago, and also as they will be hundreds of thousands of years hence.

Ever since men were interested in the heavens they have made devices by which the motions of the Sun, Moon and planets could be shown with more or less accuracy. But till the coming of the planetarium, the models were only a poor makeshift. This new device is so realistic that it is difficult when sitting beneath the dome not to believe that one is actually looking at the heavens, and not at a mere representation of them.

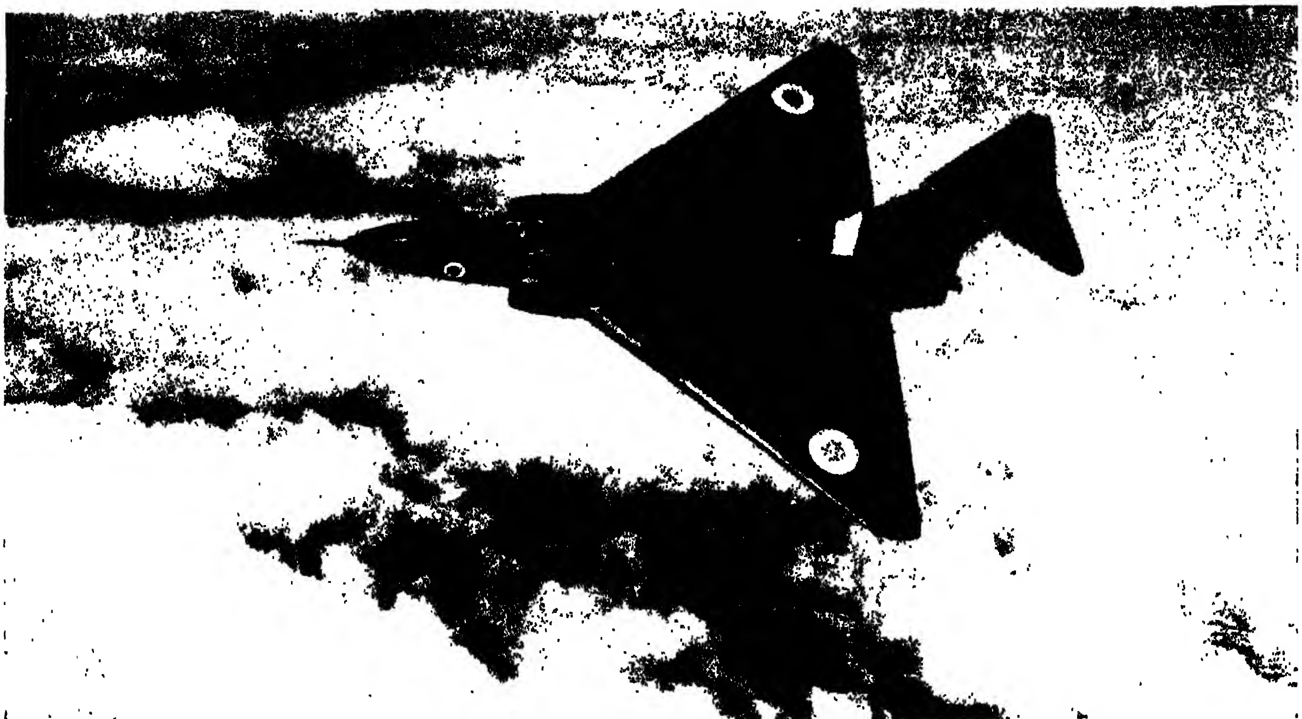
When twelve months are compressed into a space of two or three minutes we can see the planets following one another about the sky rapidly in the same paths that they follow in the heavens so much more slowly.

When a display is given in the planetarium an astronomer lectures and points out the various planets and stars and describes them and their movements. He uses a pointer to indicate any particular star he is describing at the time, but the pointer is not of wood or metal, it is composed of light, being a beam from a powerful electric torch that can be directed to any spot.

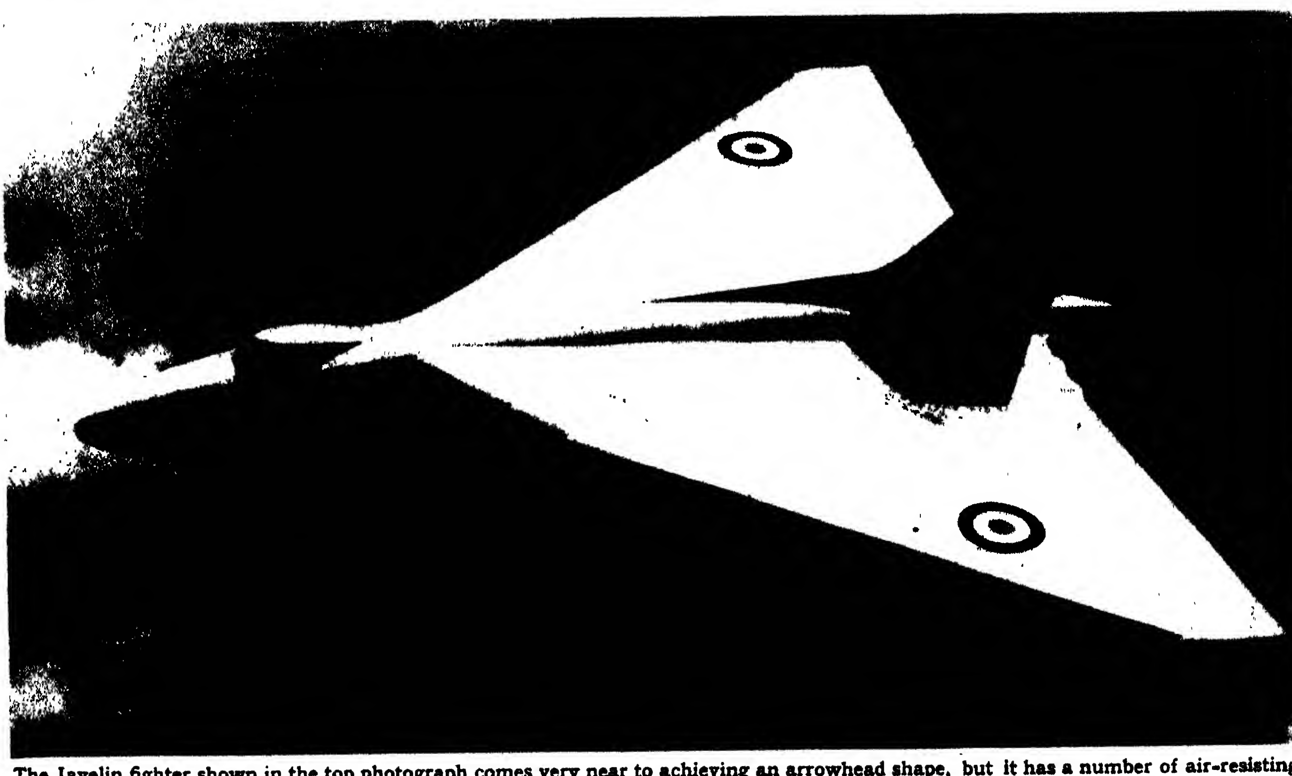


A demonstration going on inside a planetarium. The marvellously intricate projector has thrown on the dome hundreds of points of light to represent the stars and planets and a lecturer is using, as a pointer to indicate the various objects, a powerful beam of light

TWO TYPES OF FLYING ARROWHEADS



Ever since the Wrights built and flew the first practical aeroplane, designers have been dissatisfied with the shape of aircraft. Every projection on the wing and fuselage increases drag, or the resistance of the air to a moving body ; and the effect of drag is to reduce the speed of the aeroplane. No matter how powerful the aeroplane's engines, there comes a point when the engine must develop a power out of all proportion to the extra speed obtained. Therefore it is much more efficient to make the shape of the aeroplane help to overcome air resistance. The ideal shape for any body moving through the air is that of an arrowhead, and many aircraft are now built like that. An example is shown in the above photograph of the Gloster Javelin fighter, ordered for the Royal Air Force in 1951.



The Javelin fighter shown in the top photograph comes very near to achieving an arrowhead shape, but it has a number of air-resisting projections, noticeably the engine nacelles and the high fin and tail plane. In the bottom photograph you see the Avro bomber which, when it first flew in 1951, came most nearly to repeating the clean lines of an arrowhead. The intakes for the four jet engines are mounted level with the wing, while the fin and rudder, rising directly from the rear, offer very little air resistance. Aeroplanes with this shape of wing are called delta aircraft. Despite their shape, delta-wing aircraft are easier to fly than are square-wing aeroplanes.

THE BIRTH OF THE RAILWAY

It is to English inventiveness and enterprise that the world owes the railway. Both rails and locomotives were English inventions, and it is no exaggeration to say that these have done more to transform the world than any other mechanical invention since man appeared. Here is the story of their beginning

EVEN in England in the days before railways a village twenty or thirty miles from a town was practically isolated. Roads were bad, transport was difficult, and each little community, whether of a town or village, lived a more or less self-contained life, knowing little of the world outside.

North America had been peopled along the coast for several centuries, but as soon as the railway came the whole of the vast country from ocean to ocean was soon opened up. The railway followed the pioneer, and maintained the advances that had been made.

Ships might bring the products of the ends of the Earth to the ports, but without railways these would never have reached the interior parts of the country, giving that rich and varied existence which was unknown even to the wealthy before the coming of the railway.

In 1700 it took a week to go from London to York, and even two days to reach Tunbridge Wells, which is now only an hour's run by train from Charing Cross.

Difficult Roads

In the middle of the eighteenth century travelling in carriages or coaches, except on the main roads or near big towns, was practically impossible in winter, and when well-to-do persons went from one part of the country to another they usually had to have additional horses attached to their carriages to pull them through the mud, and sometimes a body of men with spades and pickaxes to clear and prepare the road or dig them out when their vehicles were stuck.

There is a letter in existence from a servant of the Duke of Somerset, who had a house at Guildford, stating that the Duke intended to set out for Petworth in Sussex on a certain day, and directing that "the keepers and persons who knew the holes and the sloughs must come to meet His Grace with lanthorns and long poles to help him on his way."

When the King of Spain and Prince George of Denmark travelled to London in 1703 their coach was overturned and stuck fast in the mire. When it was righted once more, we are told, it would have been upset again "if the nimble boors of Sussex had not frequently poised it or supported it with their shoulders from Godalming almost to Petworth." It took a king and a prince six hours to travel nine miles on this road.

Although in the early days of the nineteenth century the roads were greatly improved, and what were regarded as fast stage and mail coaches ran upon them, the discomforts of travel were very great. There were dreary waitings at roadsides in the small hours of wintry mornings for coaches which, when they arrived, were often full.

Modern travellers have little conception of the discomforts and perils of travel only a century and a half ago. "To be perched," says one writer, "for perhaps twenty hours, exposed to all weathers, on the outside of a coach, trying in vain to find a soft seat, sitting now with the face and now with the back to the wind, rain or sun, to endure long and wretched winter nights when the passenger was half starved with cold and the other half with hunger, was a miserable undertaking, and was often looked forward to with no small anxiety by many whose business required them to travel.

On Saturdays after he had finished work, Stephenson used to take his engine to pieces to gain a knowledge of its working

"Nor were the inside passengers much more agreeably accommodated. To be loosely packed in a little, straight-backed vehicle, where the cramped limbs could not be in the least extended nor the wearied frame indulged by any change of posture, was felt by many to be a distressing experience."

The coming of the railway and the locomotive changed all this. Even the poor can travel in comfort, and as rapidly as the rich, and a journey across England or from London to Edinburgh is nothing more to-day than a pleasant outing.

Everyone who travels by train to-day and everyone who finds his post and his newspapers and his milk for breakfast waiting for him when he comes downstairs in the morning should take off his hat to George Stephenson, the genius who made all these amenities possible for us.

George Stephenson was not the inventor of the railway, nor did he invent the locomotive, in the sense of being the first man to think of a vehicle to be driven by steam. There had been railways before the days of Stephenson, and there were also locomotives before the *Rocket*.

Trains Drawn by Horses

The first railways were for the purpose of conveying coal from the colliery where it was mined to the river, where it was loaded into ships for transport. In order to help the bulky carts to travel more easily rails of timber were laid down, on which the wheels moved. In this way one horse could draw four or five chaldrons of coal, a chaldron being 36 bushels weighing a ton and a quarter. On the road without rails the horse could draw only one chaldron.

There were many of these railroads in the mining districts, and then at Colebrook Dale, where the first iron bridge in the world was erected, an iron railway was laid down in 1760. The reason for forming this iron railway is curious and interesting.

The price of iron had fallen and it could not be made and sold profitably. But instead of closing the furnaces it was decided to keep them at work, cast the iron into plates, and then lay these plates on the upper edge of the wooden rails until the price of iron rose again. Then, in the case of a sudden rise in price, the iron plates

could be taken up and sold as "pigs." The iron railroad, however, was so successful that the plates remained undisturbed, and iron rails were gradually adopted in other districts. One iron railway in Derbyshire was six miles long, and in 1811 there were in South Wales 180 miles of iron railways completed. On these two horses were able with ease to draw a train of loaded trucks weighing 24 tons. To move such a load on an ordinary road of that period would have required 400 horses.

In the first year of the nineteenth century an Act of Parliament was passed allowing for the construction of an iron railway for the carriage of merchandise from Wandsworth to Croydon, on the outskirts of London.

One ordinary horse on a good road can draw about 15 hundredweights, and a particularly strong horse perhaps 2,000 pounds. When this Surrey Iron Railway was completed twelve wagons were loaded with stones till each weighed three tons, and a horse was able to draw them with ease a distance of six miles in an hour and three-quarters. During the journey other wagons were added, which did not appear to diminish the power of the horse at all, and at the end of the journey the load was found to weigh more than 55 tons.

So great was the success of this railway that it was suggested that lines of rails should be laid along the sides of all the turnpike roads in England.

As commerce increased the need for better communications and transport became more and more obvious. The canal companies, feeling that they had a monopoly, made extravagant charges and were at the same time very inefficient in their methods.

A body of enterprising business men wanted to build a railway between Stockton and Darlington for the carriage of coal, but the scheme had to be presented three times before it received the sanction of Parliament. An application in 1818 was defeated by the Duke of Cleveland and his friends, because the line threatened to interfere with one of His Grace's fox covers. Road trustees spread a report that the owners of the tolls would suffer greatly. At last in 1821 the Bill passed. The question then arose whether horse or steam engines should be used to draw the trucks, and George Stephenson, who was appointed engineer, strongly advocated the use of steam locomotives. He managed to convince his employers, and steam was eventually decided upon.

It was the success of the locomotives on the Stockton and Darlington Railway that led to the rapid development of railways all over the country, and indeed all over the world.

Who was this man to whom the world owes so much? Well, George Stephenson was undoubtedly a genius. He had little to help or encourage him in his early days, for his was a hard life.

Typical trains on the Liverpool and Manchester Railway just after it was opened. The top train is a first class one, the lower a second class

Born at Wylam, near Newcastle, on June 9, 1781, he was the son of a colliery fireman. While quite a child he went to his first employment, which was that of herding cows. Then he became a driver to the horses at the colliery, and when only fourteen was made assistant fireman to his father. In the following year he became a fireman on his own account.

Up to his eighteenth year he was unable to read, but at that age he began to go to a night school in order to learn to read and write.

Stephenson Turns Cobbler

At the age of twenty he became a brakesman, that is, the man in charge of a winding engine at a colliery. The wages were very small, and as Stephenson wanted to get married he earned a little extra money by mending boots. He did the work very well, we are told. The following year he was married and then obtained the post of engineman at a colliery.

He still found it necessary to supplement his wages, and did this by cleaning and repairing clocks and watches. His wife died in less than four years, leaving him with a young son only a little over two years old.

He went to Scotland for a time, and then returned to the Killingworth Pit, where he had been employed before. Stephenson wanted to get on, but his prospects seemed so poor that he seriously thought of emigrating to America. He had not only his young son to keep, but also his father and mother, his father having become incapable of work.

Then he was drawn for the militia, and in order not to go away and serve, leaving his people uncared for, he had to find money to pay a substitute.

Stephenson was in charge of the engine at the Killingworth Pit, and every Saturday after work he used to take his engine to pieces in order that he might gain a thorough knowledge of its working. There was a Newcomen engine which went wrong, and would no longer do the pumping of the colliery. Stephenson took this to pieces and putting it together again made it work more efficiently than it had ever done before. As a result he was appointed enginewright to his colliery, with wages of £2 a week.

This was in 1812. Stephenson was now in more comfortable circumstances, but he still tried to improve himself, and he invented a miner's safety lamp. It is curious that at the very same time Sir Humphry Davy also invented a lamp. The principle of both was alike, but the men had arrived at their conclusions by different paths. There is no doubt that the two inventions were independent, and when a national testimonial was presented to Davy, another testimonial was raised for Stephenson, and he was presented with £1,000.

The need for better transport had drawn attention to the question of steam locomotion. William Murdoch, an assistant of James Watt, had made a working model of a steam vehicle as far back as 1784. Then four years later Richard Trevithick constructed a steam carriage which actually ran in Cornwall, and was later shown in London.

In 1811 a locomotive built by John Blenkinsop hauled the coal wagons at a colliery near Leeds. Blenkinsop had no idea that smooth wheels would run on smooth rails, and so his locomotive train ran on rack rails with cog wheels. The whole thing was very clumsy and did not work very well. It was con-

stantly getting off the rail, and when the driver was one day asked how he got on, he replied, " Get on ? We don't get on, we only get off ! " Horses then had to be sent to drag the wagons and haul the engine back to the workshops. It reminds one of the early days of motor-cars.

George Stephenson thought a good deal about the matter. He was convinced that there was no need for a rack rail and cog wheels, and supported by the owners of his own colliery, he built a locomotive in 1813 with smooth wheels. When tried it worked very well and drew a train of loaded trucks weighing 30 tons up an incline at four miles an hour.

Soon afterwards he took out a patent for an improved locomotive, with springs and a steam blast. By means of the latter the intensity of combustion was maintained and the production of steam increased, so that the speed of the vehicle could be kept up.

It was all this experience which made Stephenson realise that the traction of the future would lie with steam locomotives rather than with horses.

When he obtained the sanction of the directors of the Stockton and Darlington line to use steam power in the form of a locomotive, he set to work to improve his earlier engines. He had invited the directors to Killingworth to see his locomotive there.

The Triumph of Steam

" Come and see my engines at Killingworth," he said, " and satisfy yourself as to the efficiency of the locomotive. I will show you the colliery books, that you may ascertain for yourself the actual cost of working, and I must tell you that the economy of the locomotive engine is no longer a matter of theory but a matter of fact."

So satisfied were the visitors with the power and capabilities of the engines they saw that they had no hesitation in declaring for steam power.

Three of Stephenson's locomotives were ordered for the new railway, and the first of these to be delivered, named the *Locomotion No. 1*, weighed about eight tons. The combustion in the furnace was quickened by the steam blast in the chimney, and the heat raised was sometimes so great that the chimney became red-hot.

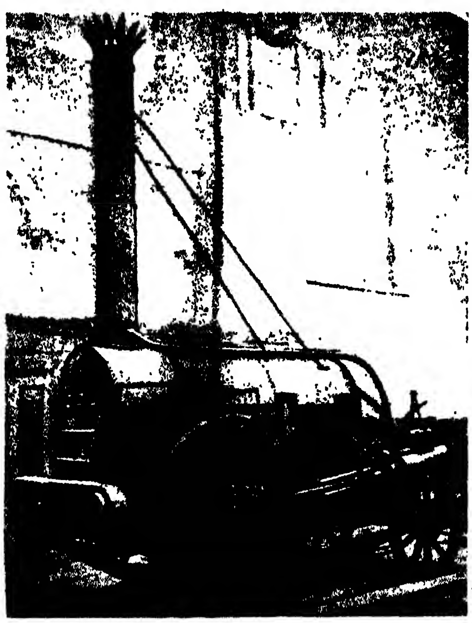
When the railway was nearly ready for opening, a small dinner was held for Stephenson and his assistants, at which Stephenson said: " Now, lads, I venture to tell you that I think you will live to see the day when railways will supersede almost all other methods of conveyance in this country, when mail coaches will go by railway and railroads will become the great highways for the King and all his subjects. The time is coming when it will be cheaper for a working man to travel on a railway than to walk on foot."

At last, on September 27th, 1825, the new line was opened. A great crowd assembled, and in Darlington there was a general holiday. A train was drawn up and Stephenson's locomotive was attached. There were six wagons loaded with coal and flour, then a covered coach containing the directors and principal shareholders, then 21 coal wagons, fitted up for passengers and all crammed full, and lastly six more wagons loaded with coal. In front of the train was a man on a horse carrying a flag.

Presently word was given to start. The horseman began to trot, and Stephenson's engine puffed while the train began to move.

The story is told of an old lady who seeing the engine standing there before the start said, " It'll never go," and then when it went off, exclaimed, " It'll never stop ! "

Soon the train began to get up speed and some gentlemen on horseback galloped across the fields to keep up



George Stephenson's famous locomotive, the *Rocket* that beat all records

with the train. At a favourable part of the road Stephenson determined to test the speed of his engine, and he called to the horseman with the flag to get out of the way. Then Stephenson put on steam, and the speed at once increased to 12 miles an hour, and at one part of the road to 15. All the horsemen were soon left behind, and when the train triumphantly steamed into Darlington there was loud cheering. *Locomotion No. 1* had drawn a train weighing altogether 90 tons, and carrying besides the coal and other merchandise 450 passengers.

Then the train was rearranged, the six loaded coal wagons were left behind, and other wagons containing 150 more passengers were attached, together with a band of music. The train started off for Stockton, which it reached in three hours.

As a gala opening day, September 27th, 1825, was a huge success. But when the railway settled down to real hard work would it be equally successful ?

It was soon seen that success was assured. The conveyance of passengers had formed no part of the original scheme, but passengers soon insisted upon being taken regularly, and carriages for their conveyance had to be built.

The great work of the railway, however, was the conveyance of minerals and goods. Stephenson's locomotive could draw after it at the rate of five miles an hour a train weighing 92 tons, and the rate per ton for the carriage of light merchandise between Stockton and Darlington was reduced from 5d. to one-fifth of a penny per mile, and the price for the carriage of minerals from 7d. to 1½d. per ton per mile. Coal at Darlington at once fell in price from 18s. to 8s. 6d. per ton.

It was a staggering result, and people began to think there might be something in Stephenson's prophecy that railways were the transport of the future.

On October 29th, 1824, was issued the very first railway prospectus ever drawn up. It was that of the Liverpool and Manchester Company, and stated that railways held out to the public not only a cheaper but a far more expeditious mode of conveyance than any yet established.

A Great Historical Document

" In the present state of trade and of commercial enterprise," said the prospectus, "despatch is no less essential than economy. Merchandise is frequently brought across the Atlantic from New York to Liverpool in 21 days, while owing to various causes of delay goods have in some instances been longer on their passage from Liverpool to Manchester."

Then the prospectus went on to explain that "coal will be brought to market in greater plenty at reduced rates, and farming produce of various kinds will find its way from greater distances and at more reasonable rates. To the landholders also in the vicinity of the line the railroad offers important advantages in extensive markets for their mineral and agricultural produce, as well as in a facility of obtaining lime and manure at a cheap rate in return.

" Moreover, as a cheap and expeditious means of conveyance for travellers the railway holds out the fair prospect of a public accommodation, the magnitude and importance of which cannot be immediately ascertained."

As a historian has said, this prospectus may be regarded as a great historical document.

When the matter came before a

committee of the House of Commons, George Stephenson, who had been appointed to make the necessary surveys for the preparation of plans, was called to give evidence. We are told that with his Northumbrian dialect he found it difficult to make himself understood by the Members of Parliament. He himself was convinced that the line was practicable, and he could say something about locomotives, for he had now built sixteen, but it was not so easy to convince a lot of old gentlemen in Parliament.

One of the difficulties of the proposed line was that it would have to pass across Chat Moss, a stretch of boggy territory which, as was explained, "rises in height from the rain swelling it like a sponge, and sinks again in dry weather." If a boring instrument were put into the ground it sank immediately by its own weight. But Stephenson felt sure that he could conquer Chat Moss.

After hearing all the evidence Parliament rejected the scheme, but another attempt was made, and at last an Act was obtained.

George Stephenson's £1,000 Salary

George Stephenson was now appointed principal engineer with a salary of £1,000 a year. The line was almost completed before the motive power was decided upon. There were three propositions, first horse power, secondly locomotives, and thirdly, stationary engines with a rope to draw the trucks.

Eventually it was decided to use locomotives, and all that the most optimistic thought was that the trains might be made to convey passengers at a speed equal to that of coaches.

The provision of a suitable type of locomotive was thrown open to competition, and three locomotives were entered, one built by George Stephenson called the *Rocket*, another known as the *Novelty*, and a third the *Sans Pareil*.

At last came the great day for the testing of the locomotives. A piece of railroad was selected which was only a mile and a half long, and each engine had to travel the whole distance backwards and forwards ten times, making a journey of thirty miles. A judge was stationed at each end of the course to note the exact time at which the engines passed, additional ground being allowed at each end for getting up speed.

The *Sans Pareil* when examined was found not to have been constructed in accordance with the stipulations laid down, but it was allowed to take part in the trial. On its eighth trip the pump failed, and it was out of the running.

The *Novelty* passed between the stations only twice when the joints of its boiler gave way. Then the *Rocket* was tested, and with a load of 17 tons attached performed the distance of 30 miles twice, the first time in two hours and a quarter, and the second in two hours and seven minutes. Its greatest speed was 30 miles an hour, and the average speed 14

There was no question now about its superiority, and Stephenson was immediately ordered to build the engines for the railway.

The *Rocket* was a great improvement on earlier locomotives. In addition to the steam blast it had also a tubular boiler, so that a very large surface of water was in contact with the heat. The *Rocket* also used less than half the coal of its rivals.

On September 15th, 1830, the line was opened in the presence of the Duke of Wellington, who was then Prime Minister, Mr.—afterwards Sir—Robert Peel, the Home Secretary, the Rt. Hon. William Huskisson, a Member of Parliament who had been a Cabinet Minister,

George Stephenson in the days of his prosperity

and a number of other persons of importance.

The first train had 33 carriages all packed with distinguished passengers and accompanied by a band of music. The train started from Liverpool, but while the engines were stopping to take in water at Parkside, Mr. Huskisson and some other gentlemen strolled along the line. As they were returning to take their seats another train of carriages came up

An Unfortunate Beginning

All ran for shelter, but unfortunately Mr. Huskisson went to the side of the train and opening the door tried to enter. The door swung back and he fell to the ground, when he was run over by the other advancing train. He was so badly injured that he died the same evening, and thus a damper was thrown upon the proceedings.

The train passed successfully to Manchester, but the festivities that had been arranged were abandoned owing to the gloom occasioned by the tragedy.

There was a procession of six trains all drawn by Stephenson engines, and a Member of Parliament who was present wrote some years afterwards: "I know nothing comparable in the history of science to that triumphant march, for such it was, when the Liverpool and Manchester Railway was opened."

The railway was a triumphant success. The saving to manufacturers in Manchester in the carriage of cotton alone soon amounted to £20,000 a year, and the passenger traffic, which had been calculated at £10,000 a year, brought in ten times that amount.

There was now no doubt about the possibilities of the railway system, and soon there were projects for railways in all parts of the country. But there was tremendous opposition from various classes of people. Some good people thought it must be wrong to rush through the country at 30 miles an hour, others disliked such a dramatic change in the methods of transport.

Then there were the vested interests, the owners of turnpikes and stage coaches and post-chaises, and the breeders of horses. And finally there were the landowners, some of whom did not want the railways to pass through their estates at all, and others who saw a magnificent chance of extorting vast sums for the smallest privileges.

The Unenterprising Universities

We often hear of the enterprise of the universities, but in those days the universities of Oxford and Cambridge must have had very little enterprise and no foresight. When they could not prevent the railway they insisted upon the station and the track being placed far away from their colleges. Oxford, indeed, insisted on the insertion in the Parliamentary Bill permitting the Great Western Railway to be formed, of a special clause prohibiting the formation of any branch to Oxford.

Perhaps we should not be surprised at the attitude of these universities, seeing that even in these days one at least of the colleges at Cambridge will allow nothing more modern in the way of lighting in its Combination Room than candles, the kind of illumination that King Alfred used.

The mere rumour that there was a proposal to bring a railroad within a dozen miles of a neighbourhood was generally sufficient to bring about the presentation to Parliament of many adverse petitions. Newspapers helped in the campaign against railways. Householders were warned that their homes would be in hourly danger of being burned to the ground; farmers were assured that not only would their crops be burned by sparks from the engines, but that their hens would not lay, their cows would not graze and their game would fall dead if they attempted to fly over the tracks whose air was poisoned by the gases exhaled from the engines.

The Poet Laureate wrote in great indignation:

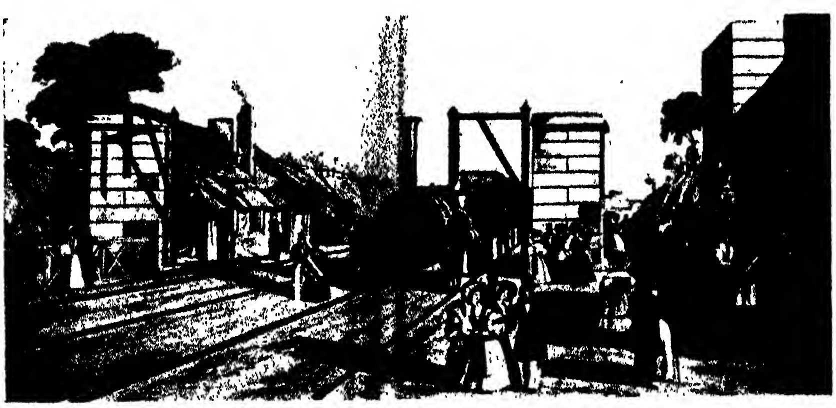
Is there no nook of English ground secure
From rash assault? . . .
Plead for thy peace, thou beautiful romance
Of Nature; and if human hearts be dead,
Speak, passing winds; ye torrents, with your strong
And constant voice, protest against the wrong

Hundreds of innkeepers and thousands of horses would, it was declared, have nothing to do. Work for the poor would be lessened and rates increased. Canals would be destroyed, and those who earned their living by them would become beggars. Houses would be crushed by falling embankments, and 27,000 miles of turnpike roads in Great Britain with other public and cross-roads would be rendered useless.

Medical men asserted that the gloom and damp of tunnels and the deafening peal and dismal glare of the locomotives would be disastrous alike to body and mind. A distinguished Parliamentary lawyer affirmed that it would be impossible to start a locomotive in a gale of wind " either by poking the fire or keeping up the pressure of steam till the boiler is ready to burst."

A well-known engineer denounced " the ridiculous expectations, or rather professions, of the enthusiastic speculator that we shall see engines travelling at the rate of twelve, sixteen, eighteen or twenty miles an hour. Nothing could do more harm towards their general adoption and improvement than the promulgation of such nonsense."

A colonel who was a great opponent in Parliament of the railways said, " I hate these infernal railways as I hate the devil."



Parkside Station, on the Liverpool and Manchester Railway, where Mr. Huskisson was killed on the opening day

One landowner when he died left his property to a relative with the condition attached that he " shall not at any time travel in or upon the Carlisle and Silloth Bay Railway," a line near his home.

Landowners who had expressed the hope that a railway would run through their district, when a line was projected opposed it, as they many times admitted, with the sole object of obtaining from the company a very large sum of money for their permission.

In one case opposition was bought off by a promise of £200,000 to be paid when the railway reached the landowner's neighbourhood. As time wore on the company's funds became scarce owing to the enormous cost of construction, and when a Bill was applied for in Parliament to release them from the construction of this portion of the line, the very landowner who had opposed the project now fought tooth and nail to prevent the company from abandoning its operations, so that he might not lose his loot.

Hundreds of thousands of pounds had to be spent in compensating these landowners. In one case a Member of Parliament who had great powers of opposition in the House, insisted that a railway company should, at a cost of £30,000, pull down and rebuild his house, which was afflicted with dry rot, and was likely to fall down at any minute. On this condition he would withdraw his opposition.

On one occasion when a witness enlarged on the injury committed by the railway in cutting up a certain property, he was confronted with an advertisement offering the land for sale, which he himself had drawn up, and which mentioned at some length the approach of the railway as adding enormously to the value.

Buying Off Opposition

It is largely because of these scandalous charges to buy off opposition that our British railways are in such an unfortunate position to-day. Millions of pounds of their capital is represented by nothing more tangible than the gracious permission of landowners to carry the railways near their estates.

Sometimes as much as £120,000 was given for a tiny strip of land, because the owner by his influence could have stopped the railway.

While mentioning these extortions it is pleasant to relate that a Duke of Bedford, after the lapse of some years, finding that his estate had benefited by the railway, returned £150,000 paid for land taken by the railway. And Mr. Henry Labouchere returned £15,000 to the Eastern Counties Railway which his father had received, when he found that his property had not deteriorated to the extent that had been expected.

The boom in railways led to a great mania of speculation such as had not been seen since the days of the South Sea Bubble. Hundreds of fraudulent companies were formed, and one had only to draw a line on a map and call it a projected trunk railway, when thousands of people, from servants to peers, would rush forward to invest their savings. Millions were lost in this way, and some of the promoters went to prison.

But nothing could stop the onward march of the railways. Before many years there was a regular network covering the country, and in the year 1843 as many as 24 million passengers travelled by train. Right through the railway era George Stephenson remained the hero. He was never spoilt by success, and his advice and help were always sound.

When a lady one day asked him about his past, he replied : " Why, madam, they used to call me George Stephenson , I am now called George Stephenson, Esq., of Tapton House near Chesterfield ; and further let me say that I have dined with princes, peers and commoners, with persons of all classes from the humblest to the highest. I have dined off a red herring when seated in a hedge bottom, and I have gone through the meanest drudgery. I have seen mankind in all its phases, and the conclusion I have arrived at is this, that if we were all stripped there is not much difference."

The benefits of railways were soon manifest. Tens of thousands of country people who had never seen London were able to pay a visit to the capital, and thousands of Londoners who had never visited the provinces were able to do so at small cost of time or money.

The food of the metropolis became greatly improved by the ease with which supplies of fresh meat and vegetables could now be brought in, and the price of coal in London was greatly reduced.

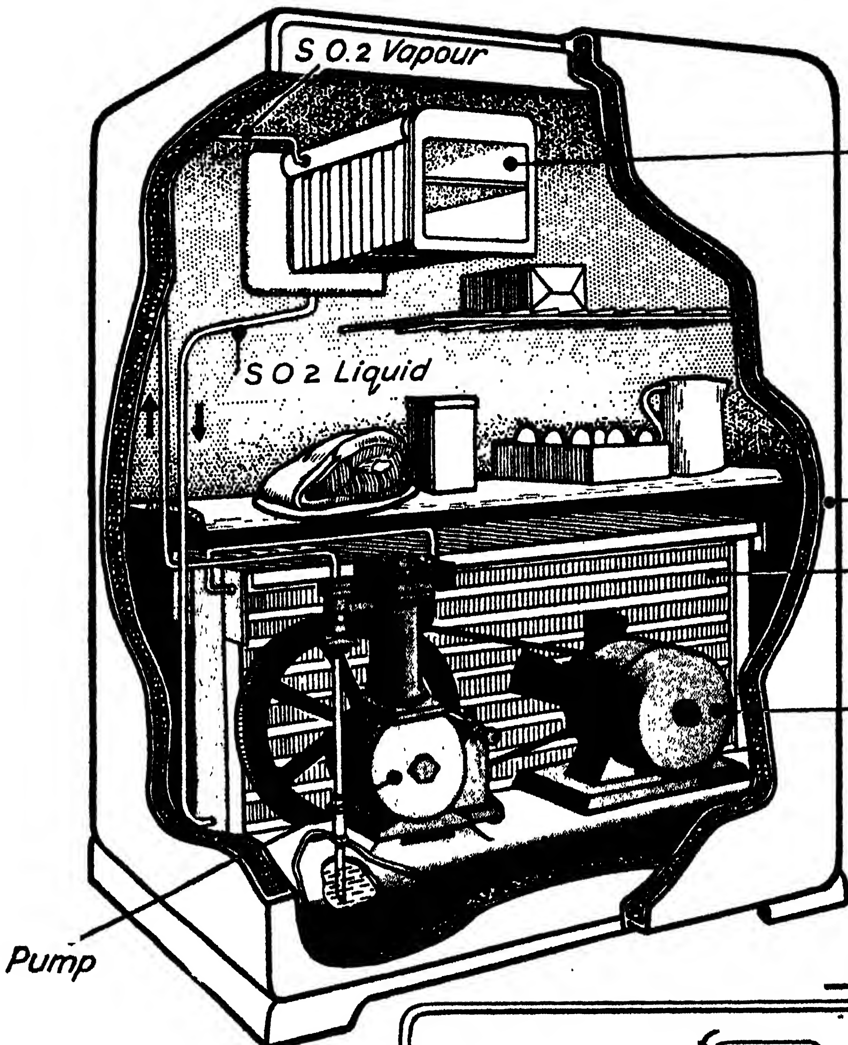
Of course, the railway companies were not always as enterprising as they might be. When in the early days it was suggested that time-tables should be prepared, a railway director strongly opposed the idea. " Why," said he, " if we publish time-tables the public will expect the trains to run at the times stated ! "

It is interesting to know why the men who work on the railway track are called ' navvies." In early days these men were labourers who had helped to make the canals for inland navigation. Because of this they were known as " navigators," a word later shortened to " navvies," and when they began making the railway the same description was used.

The navvies used to wander from place to place, and they wore a kind of uniform - a white felt hat, a velveteen coat, a scarlet plush waistcoat with black spots, and corduroy breeches.

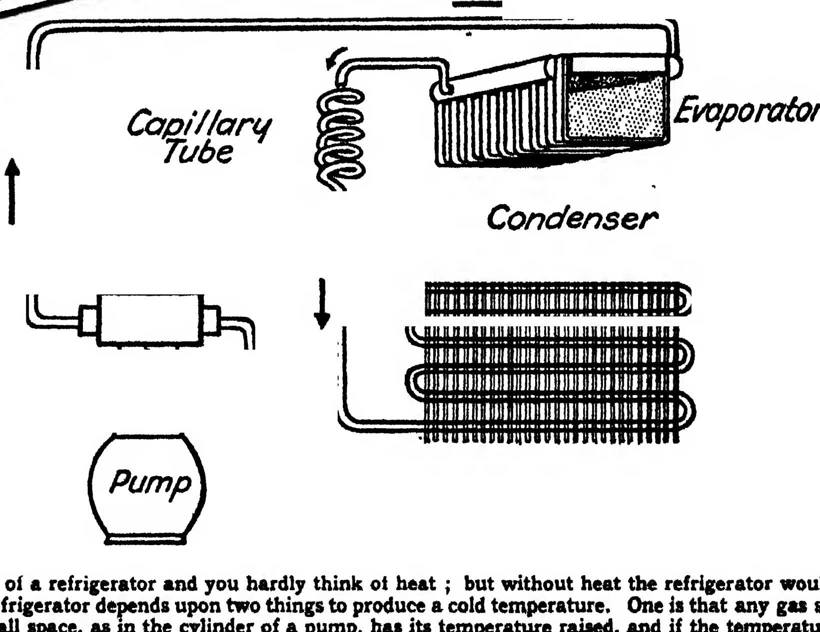
Other countries quickly adopted the railway system, and now there are more than three-quarters of a million miles of railways in the world. But it was an English idea and an English invention.

HOW REFRIGERATORS USE HEAT TO



Sulphur dioxide gas which has had its pressure raised by a compressor pump driven from an electric motor passes to a condenser. As it leaves the compressor, the gas is, of course, relatively hot. The surrounding air is forced through the condenser by a fan mounted on the motor, and this reduces the temperature of the refrigerant, and the gas liquefies. The liquefied gas then passes to the evaporator, where it absorbs the heat from the food-storage compartment, so keeping the latter cold. The liquefied gas then passes through cooling coils and again becomes a vapour.

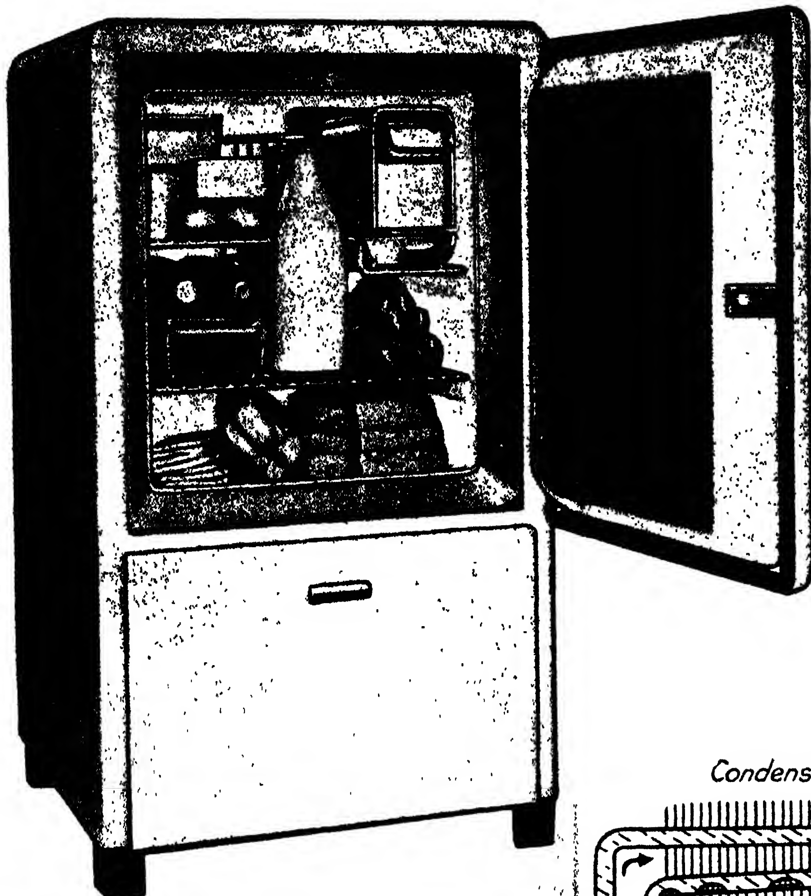
Unless a difference of pressure is maintained between the condenser and the evaporator, the compressor would merely pump refrigerant through the refrigerator and no refrigeration would result. The necessary pressure difference is maintained by a float valve (not shown here) placed in a liquid receiver near the condenser. When sufficient liquid gas has collected in the receiver, the valve is opened by the rising of the float and a quantity of refrigerant is passed into the pipe running to the refrigerator.



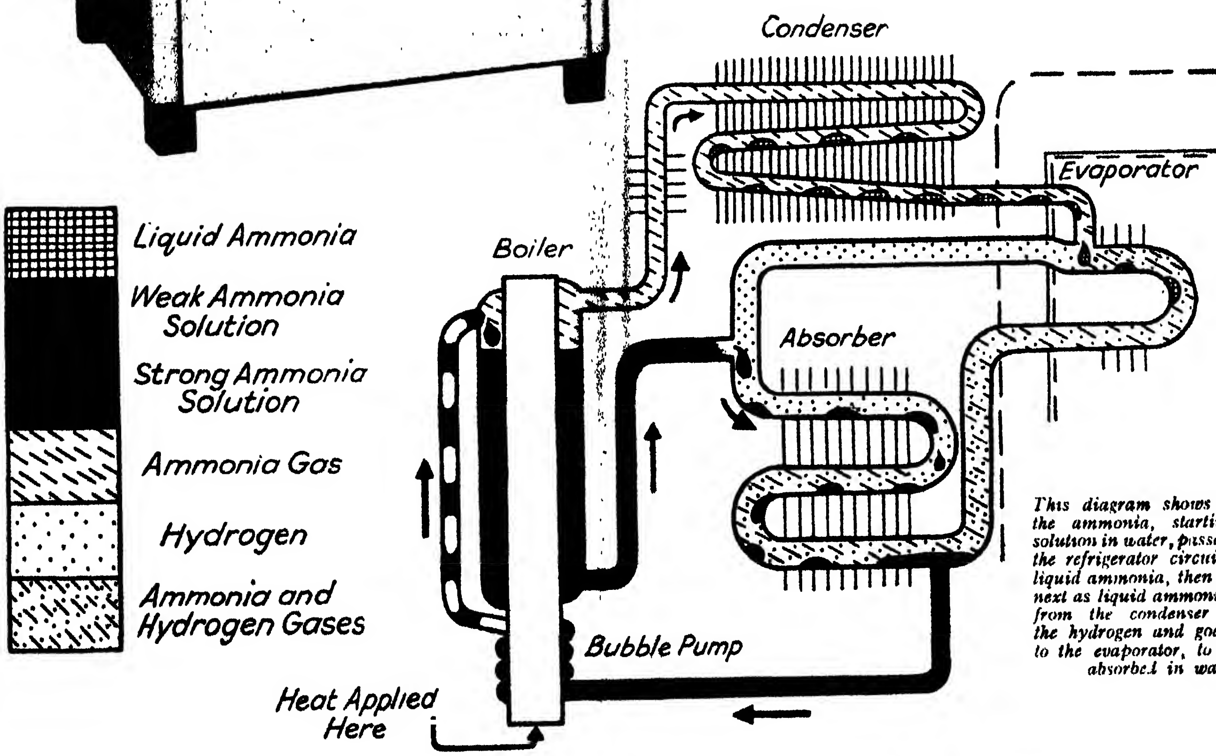
The diagram on the right shows in simplified form how the sulphur dioxide gas is forced by the pump leading to the evaporator, where it absorbs heat from the food-storage compartment and returns as a liquid to the condenser, where the heat is extracted from it, so again turning it into a vapour. The gas is then ready to be again circulated through the refrigerator.

Put your hand inside the cold chamber of a refrigerator and you hardly think of heat ; but without heat the refrigerator would not be cold inside and so keep food fresh. A refrigerator depends upon two things to produce a cold temperature. One is that any gas subjected to pressure, that is forcing it into a small space, as in the cylinder of a pump, has its temperature raised, and if the temperature of the high-pressure gas is reduced, the gas turns into a liquid. The second principle is that if a liquefied gas is allowed to evaporate it will absorb heat, and this heat turns it back into a vapour. In a refrigerator the liquefied gas circulates through an evaporator and the heat necessary to turn it into vapour is absorbed from the food-storage compartment of the refrigerator. In other words, the refrigerant, or gas responsible for making a refrigerator cold, does not actually produce the cold inside the refrigerator cabinet, what it does is to extract the heat from it. The refrigerant or substance responsible for keeping the refrigerator cool, must be a gas which when liquefied boils

KEEP FOOD IN AN ICY TEMPERATURE



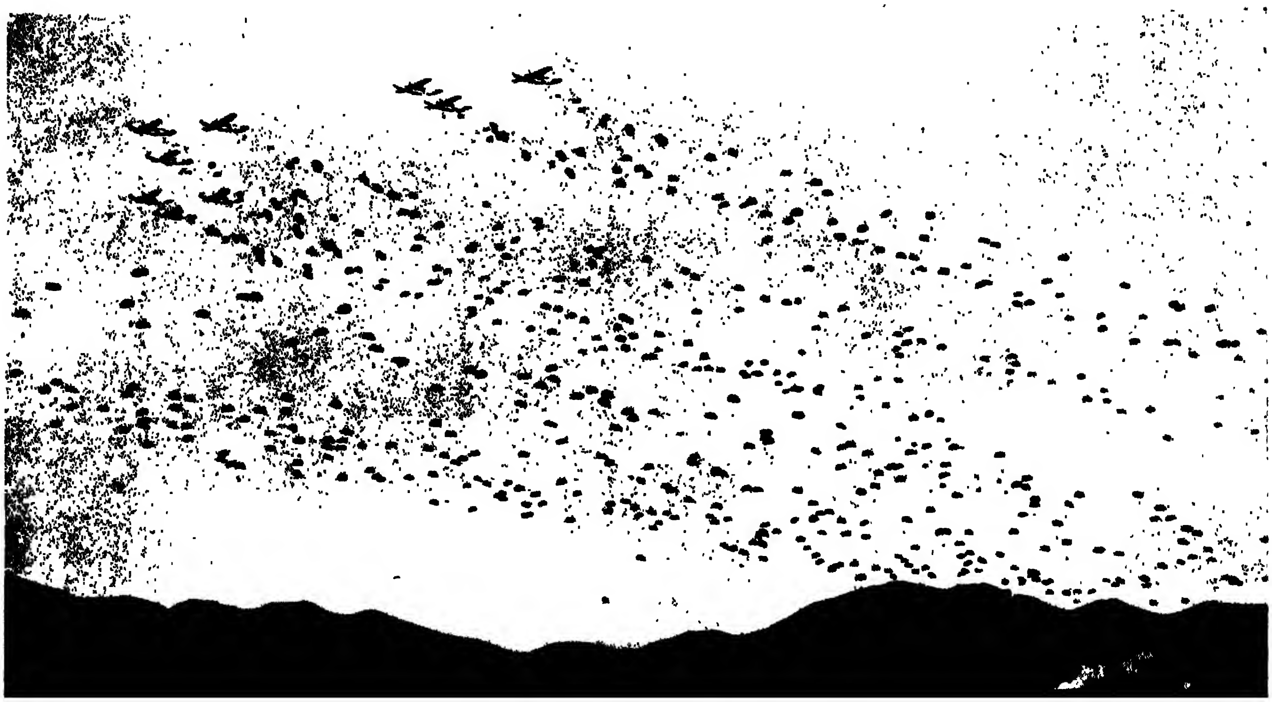
In the absorption, or gas-heated refrigerator, a strong solution of ammonia and water is heated by a gas flame, which boils out the ammonia as a vapour. From the boiling tube the ammonia vapour passes up to a condenser, where it is cooled by the air surrounding the refrigerator and turned into a liquid. Then, flowing down from the condenser as a liquid, the ammonia meets a stream of hydrogen gas, and with it passes into the evaporator. There, as in the compression or electric refrigerator, the evaporation of the ammonia absorbs heat from the food to be cooled. In the absorber, the ammonia is again absorbed into water and becomes an ammonia solution. It is then driven back by the pressure of the hydrogen ready to be boiled off by the gas flame, and so begin another refrigerating cycle. The sole purpose of the hydrogen is to provide pressure, instead of by a pump, to force the ammonia solution on its way



This diagram shows you how the ammonia, starting as a solution in water, passes through the refrigerator circuit first as liquid ammonia, then as a gas, next as liquid ammonia flowing from the condenser it meets the hydrogen and goes with it to the evaporator, to be again absorbed in water

at a temperature below the freezing point of water. One such refrigerant, liquid sulphur dioxide (SO_2) boils at 14° below freezing point, and liquid ammonia gas, another good refrigerant, boils at 28° below freezing point. In its simplest form a refrigerator's cycle of operations is as follows: a suitable liquefied gas is evaporated at a low temperature and absorbs heat from inside the cold chamber of the refrigerator, so carrying out the desired cooling. The heat thus absorbed raises the temperature of the gas, which then passes to a condenser, where circulation of cool air or water removes the surplus heat, thereby again converting the gas into a liquid. From the condenser the liquefied gas passes to a chamber where it expands owing to the energy of the heat it has absorbed. Expansion of the liquefied gas causes its temperature to drop considerably, so reconverting it into a vapour. The gas then returns to the cold chamber to absorb more heat and the cycle begins once more. There are two ways of carrying out the refrigerating cycle: the compressor or electric refrigerator, illustrated on the opposite page; and the absorption or gas refrigerator, of the Electrolux type, illustrated above.

PARACHUTES AS WEAPONS AND AS LIFESAVERS



Like autumn leaves falling to the ground, the parachute troops in this photograph have just been dropped from the aircraft that brought them over enemy territory. When the soldiers reach the ground they will at once release themselves from their parachutes and go into action as infantry to disrupt the enemy's rear and lines of communication.

This drawing shows you what happens when the pilot of a damaged aircraft fires himself into the air seated in an ejector parachute. The curtain over his face is a protection against the slipstream. In the small inset photograph the parachute has begun to open.

HOW THE AIRMAN'S LIFEBELT WORKS

This article tells you the story of the parachute and how a piece of silk and a few cords make it possible for a man to fall thousands of feet without hurting himself when an aeroplane gets out of control.

If you let a penny fall from a height it reaches the ground very quickly; but let a feather fall from the same height and it goes down much slower, while a piece of tissue paper larger than the feather will fall still more slowly. Even if the coin, the feather and the tissue paper weighed the same they would still fall at far different rates, and reach the ground one after the other. Why is this ?

All these objects fell because the Earth attracted them, and the force that attracted them to the ground is called gravitation. As the Earth's attraction or gravitation on each particle of matter is equal, it would seem that all bodies, great and small, light and heavy, should fall with equal speed. And were it not for the air they would do so. A simple experiment proves that objects having different weights and surface areas fall through the air to the earth at different speeds.

If a coin, a feather and a piece of paper are placed in a glass tube which is connected to an air pump and the tube is filled with air, the coin reaches the bottom first, then the feather, then the paper. But when, with the pump's aid, the air is extracted from the tube and the tube becomes a vacuum, that is, nearly airless, the coin, feather and paper fall to the bottom at the same time.

When bodies fall in air, they displace the particles of air by communicating to them part of their own movement. The feather and the paper, having a larger surface in proportion to their mass, part with more of their movement, because they touch a larger number of air particles, and as a result their speed is slowed down.

There is a very easy experiment to prove that if it were not for the air a disc of paper and a coin would fall at the same rate. Cut out a disc of paper the size of a penny. Now, holding the penny in one hand and the disc of paper in the other at the same height, let them fall together. The penny will reach the ground in a straight line and much sooner than the disc of paper, which will flutter about and take a considerable time to make its journey.

Next place the disc of paper on top of the penny and let them fall together. Both will reach the ground at the same time. The penny has acted as a protection to the disc of paper, preventing the resistance of the air from acting upon the lower face of the paper.

All this seems rather remote from the parachute with which an airman can descend safely from a great height, but it has an important bearing on that device. The parachute is a kind of big umbrella which, owing to its large area, offers a great resistance to the air and so with the airman attached to it it falls slowly like the disc of paper, and not rapidly as would the airman without the aid of the parachute.

The parachute is the air traveller's lifebelt and with it the occupants of the aircraft can safely reach the ground in the event of an aeroplane meeting with an accident in flight. In fact the parachute is to the airman what the lifebelt is to the sailor. But it is a curious fact that the parachute was invented before men learned to fly.

Leonardo da Vinci (1452–1519) is said to have suggested the idea of the parachute, but the first man to design and use one was a Frenchman, Andre Garnerin, who parachuted from a balloon over Paris in 1797. Garnerin's parachute consisted of a piece of cloth stretched over a bamboo framework. In 1838, John Hampden, an Englishman, made an umbrella-like parachute of canvas with which he safely descended from a height of 9,000 feet.

When a piece of paper, a feather, and a coin fall in air, they descend at different speeds, but in a cylinder from which as much as possible of the air has been extracted they all fall at the same speed, and reach the bottom together, as seen on the right.

Early parachutes were very clumsy affairs and the unfortunate parachutist suffered a great deal of oscillation, or swinging from side to side, as he floated to earth. This disadvantage was overcome by an American, Thomas Baldwin, who in 1885 made a silk parachute with a hole or vent in the top. Part of the upward rush of air against the parachute as it descended escaped through the hole so that, in effect, the parachute slid down a column of comparatively still air.

Parachutes were first used only as a form of entertainment, and towards the close of the nineteenth century parachute descents were popular spectacles at the Crystal Palace, London. It was not until the 1914–1918 war, when they were provided for the observers in kite balloons, that parachutes were used for saving life. These parachutes were attached by a cord to the balloon basket and were pulled out of their pack and opened by the weight of the wearer as he jumped.

In 1918 the manually-operated parachute was introduced for the crews of aircraft, but was not officially adopted by the Royal Air Force until 1922. This type of parachute was in standard equipment for all a except when flying jet aircraft.

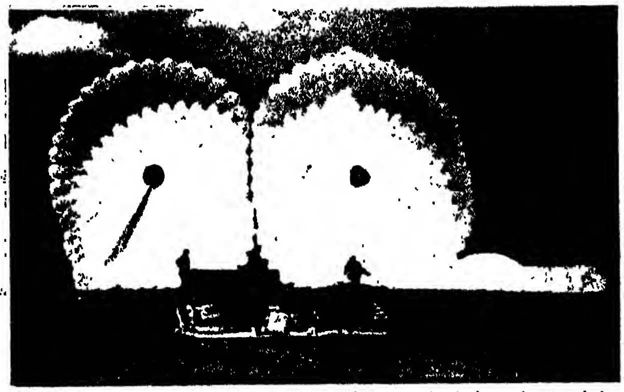
Here you see how a model parachute can be made from a square of paper. Fold the paper as shown, cut the end round, and, after opening it, fasten threads to the edge.

The canopy or umbrella of the manual parachute is of pure silk or high quality nylon and when opened is 24

feet in diameter, giving a surface area of 62 square yards. The canopy is made up from a number of small panels, so that in the event of one panel tearing during opening or descent the damage will not extend beyond one panel. Evenly spaced around the circumference of the canopy are 36 silk cords, called shrouds, and these meet at a point some distance below the opened canopy, where they are attached to the wearer's harness by a ring. On top of the canopy is a small pilot parachute which opens first and helps to pull the main parachute out of its pack.

Canopy and shrouds are folded into a pack or satchel 18 inches square, which is attached by long straps to a harness passing over the shoulders and between the thighs of the wearer, who can carry the pack on his back or use it as a seat. The folded canopy is held in the pack by a flap of material closed by two pins running through slots. Attached to each pin is a steel wire, called the rip cord, connected to a ring on the left-hand side of the wearer's belt. The packed parachute weighs 18 pounds.

When he jumps, the parachutist counts three, to give him enough time to fall clear of the aircraft, and then pulls the release ring. This jerks the pins from the slots in the pack. The pack's flap then opens, and the small pilot parachute, which is held in the pack by compressed springs, is forced out and drags after it the main canopy, which is fully open in 1½ seconds.



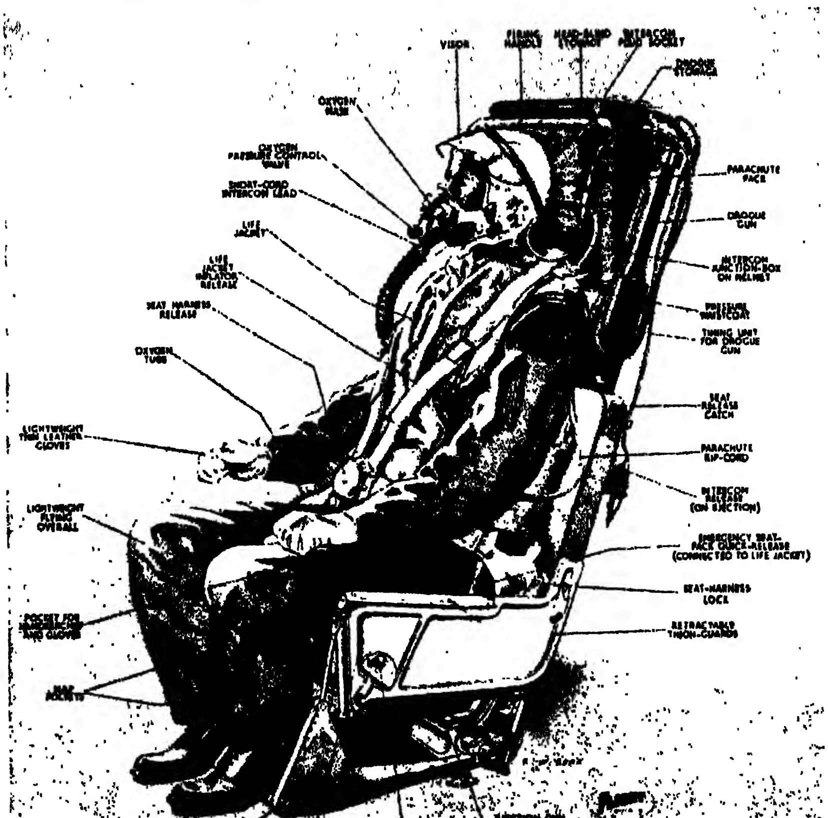
In the top photograph military equipment is being dropped by parachute from a rear opening in the fuselage of an aircraft specially designed to carry cargo. Above, a gun and its ammunition limber have safely landed on the ground. Two of the three parachutes that brought them to earth are still filled with air.

As the parachutist falls under the effect of gravity, an upward pressure of air is created below the canopy and causes it to fill with air and spread out like an umbrella. The upward pressure of air inside the canopy acts as a break, and slows down the fall of the parachute and the man suspended from it. The rate of fall is about 20 feet a second, and by pulling on the shrouds the parachutist can exercise some control over the direction of his descent.

During the 1939–1945 war, parachutes were used to drop troops and equipment on enemy territory. Parachutes for this purpose are called the static line type. This means that the parachute, which is smaller than the other kind, has the rip cord attached to the aircraft and is automatically opened as the soldier jumps. By attaching several parachutes together it is possible to drop without damage heavy equipment such as field guns, tanks and motor vehicles, and even large containers weighing several tons and called paratechnicons.

With the development of high-speed, jet-propelled military aircraft, it was found that airmen compelled to use their parachutes had difficulty in getting clear of the aircraft before the parachute opened.

Accordingly, the ejector parachute was introduced. In this, the airman's seat forms part of the parachute and runs on rails behind him. At the bottom of the seat is an explosive charge and just above the airman's head is a handle. When he pulls the handle he draws down a curtain to protect his face against the slipstream. Pulling down the curtain also pulls a trigger which explodes the charge and shoots him in his seat clear of the aircraft at a speed of 500 miles an hour. At a safe distance from the aircraft, the seat falls away, and the airman then pulls the ripcord of an ordinary parachute and floats to earth.



This photograph shows you a pilot in the seat of an ejector parachute made by the Martin-Baker Aircraft Company, England. The lettering tells you the names of the different pieces of equipment and what they are for.

BLACK RATS AND BROWN RATS

Two kinds of rats are found in Great Britain, the brown rat, which is the more common, and the black rat. Neither of these is really a native of Britain, but both have come to us from the East. They do some good, but much harm, and cost us millions a year to keep down. Here we read many interesting things about rats

ANCIENT Britain was free from rats but somewhere about the time of the Crusades the black rat arrived in ships, and it very rapidly multiplied and spread all over the country. It became a great pest, because of its destructive habits, eating up large quantities of food and gnawing its way wherever it wanted to go.

But this was not its greatest evil. It harboured and carried the microbe of bubonic plague, and there is no doubt that in England as in India, the constant outbreaks of plague, such as that of the Black Death in the fourteenth century and the Great Plague of 1665, were due to the black rat.

Early in the eighteenth century, however, another species, the brown rat, was introduced, and it proved much more virile than its relative, for in fifty years it had made its way everywhere, and by the middle of the nineteenth century the black rat was almost extinct in Great Britain

Rats from Asia

The original home of the brown rat was Asia, and it was not known in Western Europe until 1716. As it arrived in Britain in 1728, during the reign of George I, it was said that the Hanoverians had brought it into England, and it came to be known as the Hanoverian rat. Others said it came from Norway, and no doubt some did come in ships from that country, so that it was also called the Norwegian rat. Indeed, its scientific name is *Rattus norvegicus*, which means the Norwegian rat.

The strange thing is that after two hundred years the black rat has again returned to England and seems to be on the increase. It is quite common in many districts, and has been introduced from ships. Rats, indeed, are great travellers. They soon take possession of a ship once they get on board, and multiply rapidly, as they do on land. To keep them off we may often see in the docks the rope which moors the ship to the shore fitted with a large metal disc or funnel to prevent the rats from travelling up the rope on to the ship.

The animal is a powerful swimmer, and large numbers of rats have been seen to leave a ship and swim a considerable distance to the shore, probably in search of food, when stocks aboard were exhausted. In London at night whole armies of rats are sometimes seen travelling across the streets on the telephone wires overhead.

There are some interesting speculations as to how it came about that the brown rat drove out the black and how after so long the black rat has come back and is holding its own. One idea is that the brown rat, when it arrived on our shores, having had to struggle more for its existence, was much fiercer than the black rat, and so conquered it, just as the Normans conquered Saxon England, and that after a century or more of life in well-stocked England the brown rat became less fierce, while the black rat, having had to struggle more abroad, had once again acquired virility. That may or may not be the case.

Dr. Chalmers Mitchell, the scientist, some years ago wrote: "Each species has its different aptitudes, capacities and preferences, and each insinuates itself into the most suitable environment. Possibly the extension of sewers and drains in this country has been a major cause of the greater success of the brown rat."

Fighting rats by modern methods, that is with poison gas. The rat-catchers, of course, have to wear protective masks while at their work

The Two Rats

The two species of rat are often mistaken for one another, for brown rats are found which are almost black, and black rats are seen which are quite brown

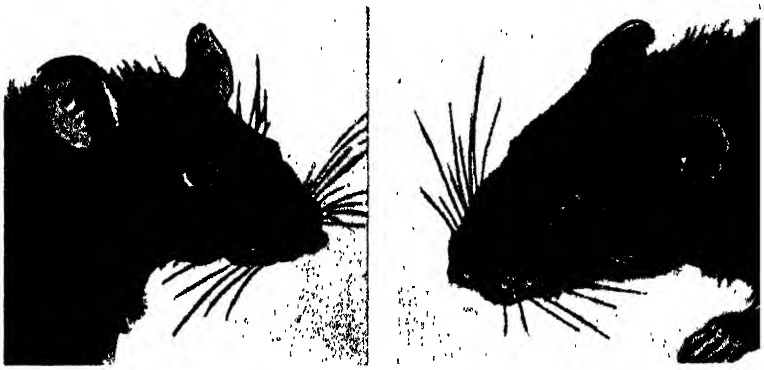
The black rat is rather smaller than the brown, slimmer in build, and has a sharper nose. Its ears are larger, and without the hair which covers the brown rat's ears, and the tail is longer and more slender. In the black rat the tail is as long as or longer than the head and body, while in the brown rat it is never so long as the head and body. The black rat very rarely weighs more than eight ounces, whereas an adult brown rat is anything from fourteen to seventeen ounces in weight. Brown rats of two pounds are not uncommon, and one

has been recorded which weighed two pounds twelve ounces.

Of course, both these animals are quite distinct from the water vole, which is often erroneously called the water rat, but is not a rat at all.

The brown rat will eat almost anything, and does not require much persuasion to turn cannibal. It eats game, fish, young birds, eggs, frogs, snails, truffles, grain, bread, potatoes and indeed practically everything which it can reach It is a wonderfully clever animal and two rats have been seen to carry eggs upstairs. The Reverend J. G. Wood, the naturalist, tells us that one lies on its back and pushes up the egg, while the other pulls it on to the step, and so they continue up the staircase

They are also among the most cunning of animals, and it is very difficult indeed to catch a rat in a trap, especially if a rat has already been inside the trap.



The head of the black rat with its pointed nose is seen on the left, and that of the brown rat on the right

A Plague Carrier

It is only in recent years that mankind has realised the menace of the rat as a plague carrier, and as a destroyer of food and property. We now have our National Rat Week every year, in which citizens of all kinds unite to reduce the number of rats, and similar united efforts are made in other countries, including India.

No one can say exactly what the rat population of Great Britain is, but estimates based on known facts vary between forty millions and a hundred millions. It can be quite understood, therefore, what a vast amount of food this voracious army must consume in the course of a year.

The smallest estimate of the national loss in Britain due to rats is £10,000,000, but some estimates by responsible people place the loss at £70,000,000. The latter figure is the calculation of the Ministry of Agriculture.

The loss caused by rats does not consist only of the food they eat and the damage they do to property by gnawing holes in floors and walls, but in the great cost of buying and setting traps and poison baits, and in the ammunition used in their destruction.

Rats are often very wanton in the destruction they do. A year or two ago the Editor placed four thousand pears that had been gathered in his orchard in the cellars, spreading them out on the floor, and in one night the whole of these pears had been damaged by rats. They had not eaten the fruit, but had merely nibbled the pears so that they became uneatable, and had to be used for manure. Not a single one of the thousands of pears was left untouched.

Rats cross the streets of London by the overhead telephone wires and go aboard ships in dock by the mooring ropes. To keep them off the ships metal shields are placed on the ropes, as shown here

In London and other large cities a vast amount of damage is done in shops and warehouses to goods other than food—hats, furs, clothes, boots, drapery and so on being nibbled and torn. In one city warehouse during a single night £80 worth of silks were destroyed by rats, and in another they attacked a hundred-guinea fur coat in order to get the material to line their nests.

The animals are very courageous, and will often put up a good fight even against ferrets. The official rat catcher to the Bank of England and several London boroughs tells us that in a building near Holborn he saw nearly fifty rats bolt, and he set seventeen ferrets after them. Then a very unusual thing happened, for the rats turned upon the ferrets, wounded most of them, and eleven were laid up for five weeks. A twelfth was bitten in 32 places, and died within 48 hours.

Armies of rats are often seen in the country crossing the roads. Not long ago two men were walking along a road on a moonlight night when they saw a mass of rats coming towards them. If they had attempted to frighten the rats or pass through the host they would probably have been killed, but they went quietly to the side of the road, climbed on a gate, and sat there motionless while thousands of rats passed by.

Motorists often kill rats on the roads at night. It is sometimes said that the light dazzles the rat so that it runs under the wheel without knowing what it is doing, but what really happens is that the rat, being alarmed, runs to the wheel to take shelter and thus gets killed.

A Rat's Progeny

The rat multiplies at an alarming rate. One female during a year will produce five or six litters, each of from eight to a dozen young rats, and before the last litters are born the first have themselves become parents. It is estimated that a pair of rats with six litters of eight in a year would, with equal sexes and no deaths, be represented by 880 at the end of the first year In the course of five years the single pair would have produced hundreds of millions of descendants.

Of course rats do some good, although it is far outweighed by the evil. They are scavengers, and if the whole race of rats were suddenly wiped out we might be in difficulties But it is the duty of every citizen to do all he possibly can to keep down the numbers, and an Act of Parliament passed in 1919 makes it a punishable offence to harbour rats or to neglect to destroy them. It is only by a united effort that the great rat menace can be met and the numbers that prey on our property destroyed.

THE RELENTLESS WAR AGAINST THE RATS

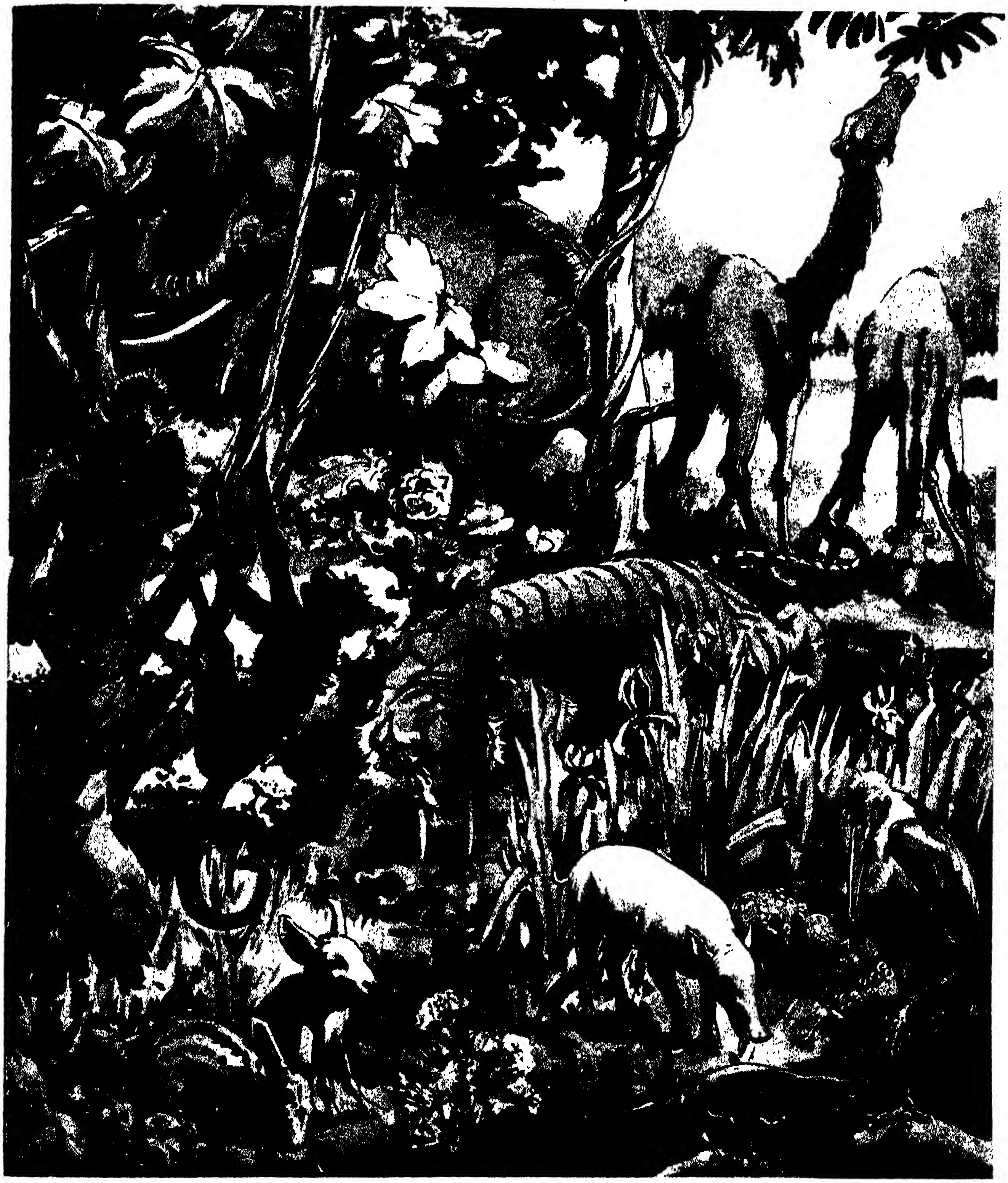
If man were to cease his warfare against the rats, these animals would multiply so rapidly as almost to contest the sovereignty of the earth with him. The rat is a cunning fellow, and only by exercising every strategy can its numbers be kept down. Here we see a battle with rats going on in the cellar of a London warehouse, the vermin being shot as they are driven out of their holes by ferrets

In the war against the rats the ferret and dog are man's allies. The rat is afraid of the ferret, and when this animal is put into its hole the rat flees. As it comes out dogs specially trained to the work seize it, and by nipping it across the spine, kill it instantly

THE ELEPHANT & HIS MARVELLOUS TRUNK

The elephant is the only animal in the world that uses his nose as a hand and arm. The early ancestors of the elephants had long noses, but we do not know why this particular family of animals should develop the nose into a trunk. Perhaps one of the early members with a longer nose than usual found that it could use it for pushing or pulling down branches of trees and its descendants learned the trick. Then gradually the noses became longer and more useful, till now the trunk has become a truly wonderful limb. It has enormously powerful muscles, and in order that these may find a suitable attachment the elephant's skull has become greatly developed in size. The skull, however, must not be unduly heavy for the animal, and so the thick bone of which it is composed is honeycombed with large air spaces, so that while it is strong and big it is also light in proportion. There are many wrong ideas about what an elephant can do with its trunk. It is sometimes said that it can pick up a needle from the ground or drag a great cannon from a bog. Experts declare that it is doubtful if the former feat can be performed, and certainly the latter could not be done. Elephants dragging great weights invariably take the rope between their teeth. They never attempt to pull a heavy weight with the trunk. In carrying a log, if it is light, they hold it in the mouth as a dog does a stick, and if it is heavy and they have tusks, they rest the log on the tusks and merely steady it with the trunk, and most generally they use their heads and feet in moving great weights. Elephants are very sensitive about their trunks, and when danger threatens invariably curl them up out of harm's way, as the Indian elephant in the photograph is doing

LIFE ON THE EARTH 1,250,000 YEARS AGO



In this picture Miss Betty Nation has reconstructed the life found on the Earth in the Miocene Period, about a million-and-a-quarter years ago, according to some geologists. The temperature of Europe was getting cooler, and plants more like those of Europe to-day flourished. There were, for instance, irises and poppies and pinks and violets. It was the age of the sabre-toothed tiger. Giraffes had not yet appeared in this age, but there was a camel-like animal with a giraffe-like neck, which enabled it to feed on the foliage of tall trees. Animals of the elephant family were growing more like the elephants of to-day, and one, the tetrabelodon, had a very long under-jaw with tusks of the modern type. A hare-like animal, but much larger than our hares, is shown at the bottom, left. It is called the toxodont, and a burrowing creature shown on the right, known as a mylagaulus, had a horn on its snout. Ape-like creatures were appearing. One of these, seen on the left, called pliopithicus, was something like the gibbon of to-day There were some birds very much like our marabou storks, auks, gulls, guillemots and curlews

BLOSSOM THAT MAY OR MAY NOT MEAN FRUIT

As we know, there is a regular routine in the production of fruit by a tree like the plum tree shown in this photograph. First comes the bud, which opens into a full blossom, and finally the fruit appears, small at first, but as the sun shines on it getting bigger, and at last ripening into the rich and luscious fruit which we find so attractive. Without the blossom there can be no fruit, but a great mass of blossom like that shown here, though bearing the possibility of a rich crop, does not necessarily mean that fruit must come Many things may happen to disappoint us. If the blossom is not fertilised, that is if the pollen from the male flowers does not reach the female flowers no fruit will result. Even after fertilisation an untimely frost may destroy the efforts of the tree to produce offspring

WHAT THE AUSTRALIAN DESERT IS LIKE

The central parts of the vast island continent of Australia consist of dry regions where little grows but scrub and porcupine grass. But the soil is fertile and there is plenty of water beneath the ground. If this can be tapped over large areas the central region of Australia should become a thriving, populous country. On this page we read something about the nature of the Australian Desert

We often hear of the great Australian Desert, but the term gives a wrong impression of what the arid regions in the central part of the great island continent are like. They are not vast stretches of shifting sand like the Sahara and the Gobi Deserts, but are more like the arid regions of North America.

They do not produce crops and sustain human and animal life because of the lack of water. There are regions that go sometimes for months and even longer without a drop of rain, but far down underneath the soil there are rich supplies of water, which only need to be tapped.

In many parts of the arid regions of Australia deep artesian wells have been sunk and supply large quantities of water. But if great areas of the interior are to be made available for settlement by civilised men, much more will have to be done in the way of well-sinking.

Proposals are already being made for the expenditure of millions of pounds in developing this great central region, and it is quite possible that human industry and enterprise may transform the wilderness into a garden. Young readers of this book may yet live to see a great rich and populous country in Central Australia, where at the present time there is little animal life at all.

If the water problem can be solved there is much wealth that can be obtained. No doubt fine and profitable crops could be grown, large flocks and herds could be sustained, and geologists tell us that there is much mineral wealth only waiting to be taken.

Instead of being a great sandy expanse, the central regions of Australia are mostly covered with vegetation of a sort. It is often stunted scrub with a great deal of what is known as porcupine grass, of no use for cattle or sheep. But after the rare visitations of rain these great plains often produce an amazing growth of herbage. As soon, however, as the water supply is dried up the herbage perishes, and the desert returns to its former scrubby growth.

It is because of the arid character of the central plains of Australia that camels were introduced many years ago for transport purposes, and they are still used. With the beasts were introduced a number of Afghans to look after them and act as drivers, and the descendants, of both the camels and the Afghans, are still doing good work in these arid regions.

The descendants of the Afghans, although they were born in Australia and have never been outside that continent, still wear turbans, and every evening turn their faces towards Mecca as they offer their prayers to Allah.

If these vast regions covering hundreds of thousands of square miles can be turned into a garden, producing crops and herds, Australia will be able to support scores of millions.

Camel transport in the arid regions of Central Australia. The drivers are the descendants of Afghans who were introduced years ago with the camels. Though these men have never been outside Australia they still maintain the customs of their forefathers

THE HOTTEST AND COLDEST PLACES IN THE WORLD

We might naturally suppose that the hottest place in the world was on or near the Equator, and the coldest place round about the North and South Poles. If we thought this, however, we should be quite wrong. The temperature of a place depends on a number of different factors—whether land or water predominates in the district; whether the atmosphere is dry or moist; whether there is much wind and the direction from which this comes; the nature of the soil on which the Sun shines, and so on.

Even when the Sun is shining with the same strength it may be much hotter at the same place on one day than it is on another. For example, it is generally much colder on March 21st, even with the same amount of sunshine, as it is on September 22nd, for on the latter day the soil, the surface rocks, if there are any, the lakes and so on, have all been warmed during the Summer, and as they cool slowly they retain and give off much of this accumulated warmth in September. On the other hand, as March 21st follows the Winter, there are no such reserves of heat.

Similarly when the Sun is at his highest in the Northern Hemisphere, it is not the hottest part of the year, for the Summer heat has not yet completely overcome the effects of the preceding Winter. As has been truly said, "The time of greatest heat lags behind the time of greatest heating."

Where then is the hottest place in the world, that is the place at which the thermometer has given the highest reading? Well, it is nowhere near the Equator. The highest reading of the thermometer properly authenticated is 134 degrees Fah. in the shade, which was recorded in the Death Valley of Southern California. So far from being on or near the Equator, this place is north of the 36th degree of latitude, and is on a level with Gibraltar, whose temperature is quite moderate. The reason for the difference is that the Death Valley is a very dry area with little stirring of the air, and masses of rock exposed to the sunshine reflect the hot rays into the atmosphere and heat it to this astonishing degree.

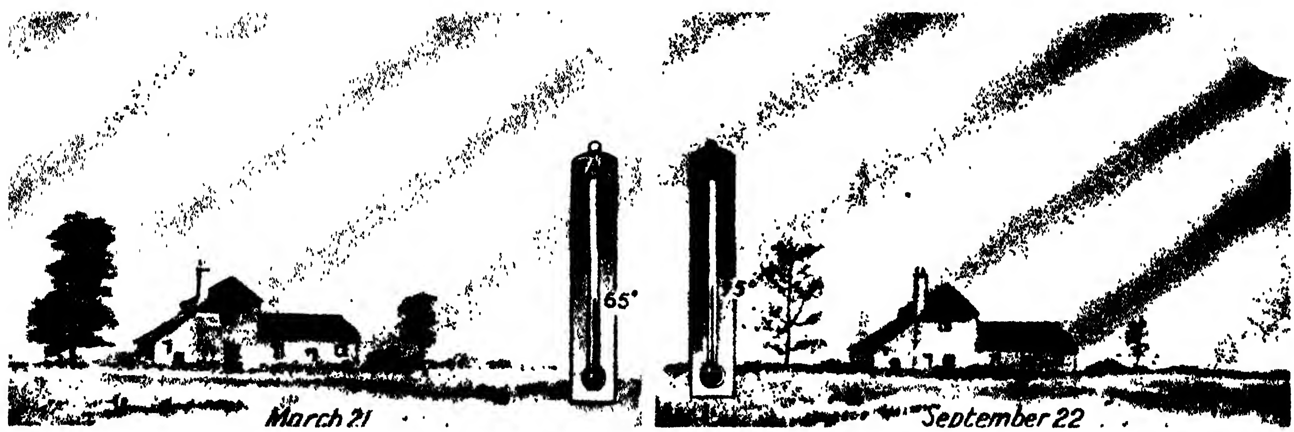
Gibraltar, on the other hand, has water all round it, except on one side, and a place near the sea always has a cooler and more equable climate and temperature than one situated like the Death Valley.

It is reported that a shade temperature of 154 degrees Fah. was read in the Sahara Desert, but this is not properly authenticated like the other.

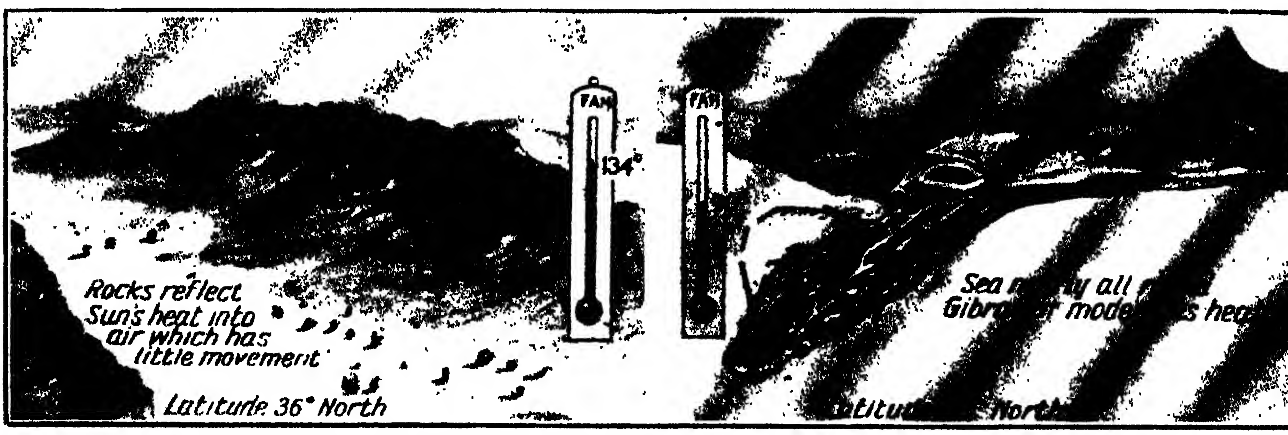
Now where is the coldest place in the world? Here again it is nowhere near the North or South Pole. It is a small town in Siberia, about 400 miles north-east of Yakutsk, and is near Verkhoyansk. Here in mid-Winter a temperature of rather more than 90 degrees below zero Fah. has been recorded, that is 122 degrees of frost. Yet this place is only in latitude 67 degrees, on a level with Norway and Sweden, and only just within the Arctic circle. It is nowhere near the sea, and not only is it remarkable for its extreme cold in Winter, but it is also remarkable for the enormous range in temperature between Summer and Winter. Though the thermometer records at times 122 degrees of frost in Winter, in Summer it rises as high as 93 degrees in the shade, a temperature we very rarely reach in London in the hottest summer.

The low temperature at Verkhoyansk in Winter is properly authenticated.

The Death Valley and Verkhoyansk are shown on page 256.



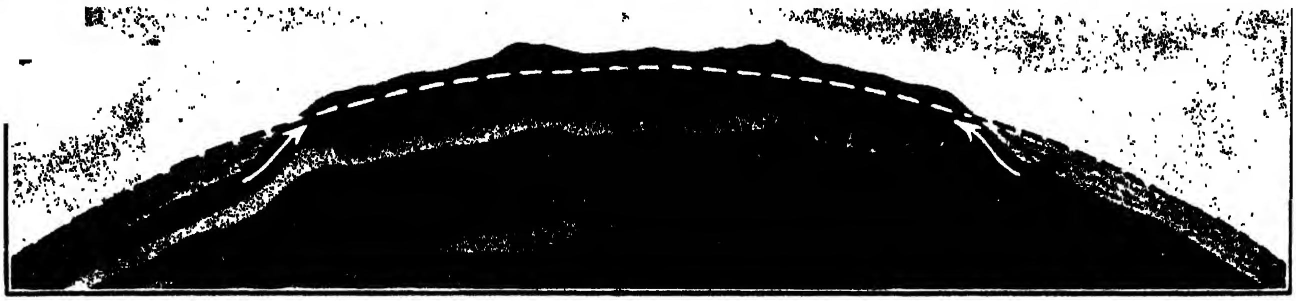
Here the same amount of sunshine is pouring upon the same place on March 21st and September 22nd, yet it is hotter in September than in March, because through the summer the soil has been taking in heat and gives off some of its accumulated warmth



The Death Valley, California, shown on the left, and Gibraltar, shown on the right, are both at the same latitude, yet the Death Valley, because of its landlocked situation, is half as hot again as Gibraltar which is almost completely surrounded by sea

HOW THE CONTINENTS AND OCEANS WERE FORMED

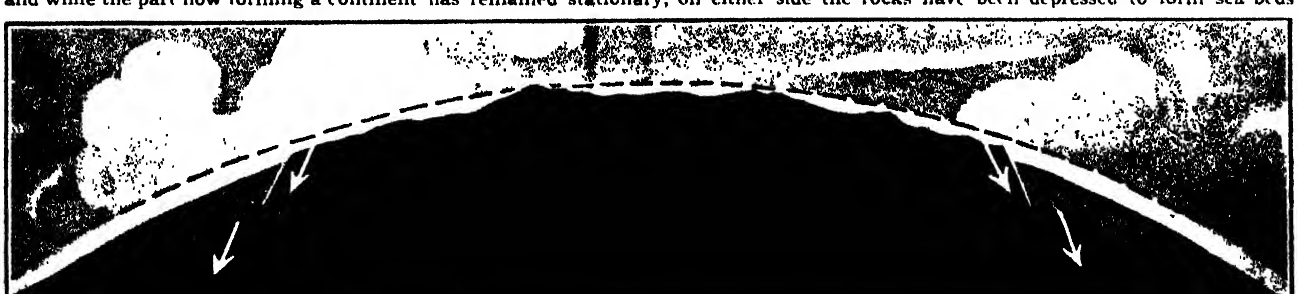
There are various theories as to how the oceans were gathered into basins and the dry land appeared. Five of these theories are shown on this page. Here the rocks have become dislocated, part rising to form a continent and part sinking to form ocean beds



In this diagram the strata instead of being dislocated have become warped, part being pushed up to form a continent, while on either side the rocks have been thrust down to form the ocean beds. The dotted line in all these diagrams represents the original surface

Here we find the same idea as in the top picture, except that while part of the rocks against the faults has been thrust down and thereby becomes ocean beds, the other part has remained stationary in its original position, and not been pushed up as in the top picture

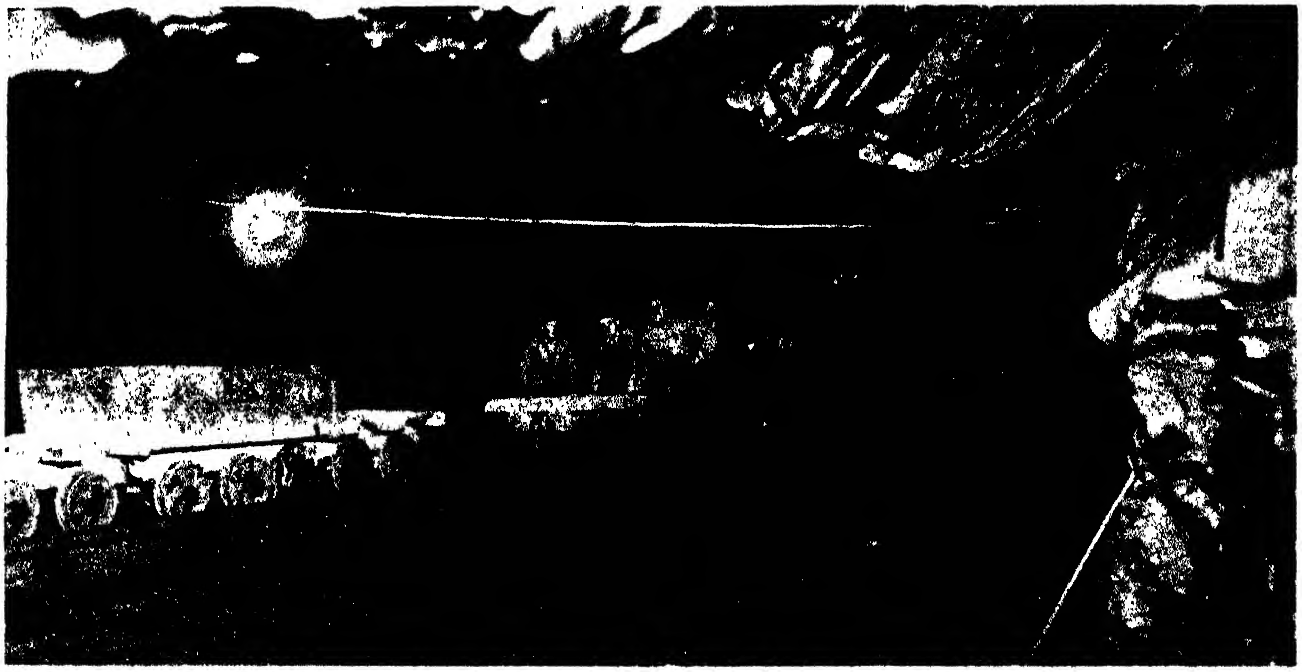
Here is another theory of the scientists. In this case there has been no dislocation of the strata, but they have become warped, and while the part now forming a continent has remained stationary, on either side the rocks have been depressed to form sea beds



In this picture-diagram we see still another theory explained. Here the rocks after dislocation have all been thrust down beyond the original level, but while the ocean beds have been pushed a considerable distance, the part forming a continent has not moved far

QUARRYING SLATE ABOVE AND BELOW GROUND

The finest slates in the world come from North Wales, where there are quarries that have been worked continuously for eight centuries. In some cases the slate is quarried from the face of the rock, as shown here, and great climbing skill is needed on the part of the quarrymen as they go about their work. Slate, which is one of the clay rocks, was originally deposited in water, and we see signs of this in the occasional bands of gritty material. In Welsh slates there are minute flakes of mica, one-2000th of an inch in breadth and only one-6000th of an inch in thickness. Slate often contains an abundance of very minute crystals



Here we see Welsh slate being quarried underground. Steep slopes are cut into the base of caverns and from these the blocks of slate are cut. Tunnels are worked one below the other. Slate depends for its value upon its cleavage. The best slates are hard and fine-grained and cleave into thin plates, sometimes not more than a sixteenth of an inch thick. Slate stands the weather perfectly, hence its great value as a roofing material. Other advantages are that it is light, thin and cheap, so that it has largely displaced other roofing materials. In quarrying slate the worker must be careful of the sharp edges which are keen enough to cut hand or foot

MARVELS of MACHINERY

THE WONDER OF THE MOUNTAIN RAILWAYS

Mountain climbing is an arduous exercise, but there are many mountains that can now be scaled even by the feeble. Instead of going up on foot the traveller can reach the summit in a comparatively short time by means of a mountain railway. Such railways are found in the Alps and elsewhere. Here we read something about the different types of railways which take travellers from the base to the summit

THE feats of the railway engineers are among the greatest triumphs of engineering in the world. No district is too difficult or inaccessible to have its railway. From the time that George Stephenson constructed the track of the Liverpool and Manchester Railway across the shaky ground of Chat Moss to the present day, the engineers have been ever conquering new worlds.

How Trains Ascend

In all parts of the world railways wind round and round the mountain slopes carrying passengers from the plains and valleys far up above the clouds. Where the system of a winding track is too difficult to carry out there are rack and cog tracks by which engines can literally climb up steep gradients, and on the Callao-Oroya Railway in Peru trains make a climb of 15,865 feet, or more than 3,000 feet higher than the highest mountain road in Europe.

There are many mountain railways in the Alps. In some cases the rack-and-pinion system is used, the principle of which is that there shall be a toothed rack between the rails running up the slope, and a powerful cogwheel under the engine engaging with the teeth of the rack and pulling the train up the mountain-side.

In other cases, as at the Wetterhorn, it has been found more convenient to construct an aerial railway with cars which hang from powerful cables supported at intervals on steel towers, and are drawn up and down the mountain by means of cables. The car remains horizontal all the time, and the cables that pull the cars up and down are moved by large drums on which they are wound and which are rotated by means of electric motors.

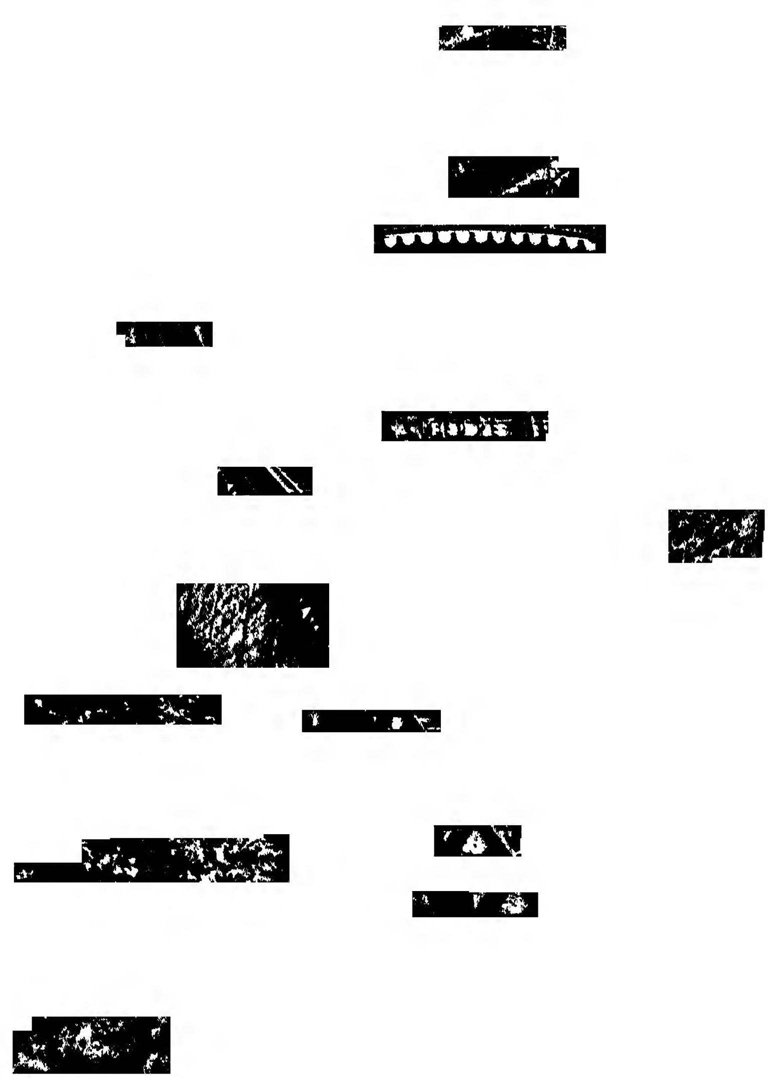
The cars used on these cable railways are fitted with various kinds of mechanism to insure safety in transit. There are brakes, for example, which are very powerful and, should a cable break, could hold the car stationary on the very steepest section of the line.

There is a double track of cables, and as one car ascends the other descends, thus working on the compensating principle so that gravitation assists in the work of transport.

The Cheaper Way

The expense of erecting a cable railway is not so great as that of erecting a rack-and-pinion, and hence it is coming more and more into favour. We have already seen on page 604 how there is an aerial railway of this type for carrying passengers from Cape Town to the top of Table Mountain in South Africa.

In regions like the Andes and the lower reaches of the Himalayas the cost of building a railway is very great, because of the difficulties of getting machinery and material to the proposed track. The greatest ingenuity is exercised



The rack-and-pinion railway in Switzerland which carries travellers up the mountain from Glion to the Rochers de Naye, overlooking the Lake of Geneva. This is a rather expensive type of railway to construct, but it is very safe as the powerful cogwheel on the underpart of the carriage engages with the rack and prevents too rapid descent

by the engineers in taking advantage of slopes in order to keep down the gradient of the track as much as possible. In many railways, like that which goes up to Darjeeling, the track doubles upon itself and after travelling round a curve goes over or under another part of the track like the loop of a string or knot.

Up-Hill Work

In building a mountain railway like the Callao-Oroya Railway already referred to, the engineer has a harassing time, for so many unexpected difficulties arise. That railway was designed and built by the famous engineer Henry Meiggs. For the first hundred miles the track climbs continuously, zig-zagging in a very extraordinary manner. Streams are bridged, galleries are hewed out of the solid rock, the rails are laid along the edges of tremendous precipices, and openings have been blasted through vast rocks. In one section of fifty miles nearly sixty tunnels had to be pierced through the rock, and as one travels in a train on the railway one can look down upon tier after tier of track, the result of the zigzagging of the line.

More than half a million pounds of explosives were used every month in blasting a way for the railway, and when Meiggs died as the result of privation and worry in making the line, two-thirds of it had been completed, and it had ascended the Andes for 88½ miles to a height of 12,200 feet.

The aerial railway which takes travellers up the heights above Engelberg in Switzerland. The cars drawn by a cable travel from Rohr to the Gerschni Alp. The steepest of the Swiss cable railways, that at Ambri-Piotta in the Canton of Ticino, mounts 2,145 feet in seven eighths of a mile

With the master engineer gone, however, the work was suspended for only a short time. Another engineer followed the originator and the work was finally completed, ending at a place just over three miles above sea-level, where the air is so rarefied that it is difficult to breathe. No wonder large numbers of workmen suffered and died when labouring in such an atmosphere.

Peace-Making

Another famous mountain railway is the Trans-Andean Railway. This track, which runs from the Argentine to Chile, has brought the Atlantic and Pacific coasts of South America within thirty hours of one another. It was a great victory for Peace, and on the summit of Mount Cumbrae stands a huge bronze statue of Christ, with this inscription on the base: "Sooner shall these mountains crumble into dust than the people of Argentina and Chile break the peace which they have sworn to maintain at the feet of Christ the Redeemer."

The highest railway in the world is the Antofagasta and Bolivia Railway, where at Montt the trains pass at height of 15,834 feet, or three miles above the level of the sea. This railway has a gauge of 2½ feet. The Central Railway of Peru runs this height close, for at La Cima the trains travel at a height of 15,806 feet above sea level. The highest railway in the United States is at Pike's Peak, 14,147 feet

HOW PLAIN CLAY IS TURNED INTO BEAUTIFUL CHINA

When the china clay comes to the works it is put through a mill and kneaded to a paste of suitable consistency

The potter takes a ball of clay, throws it upon his quickly-revolving potter's-wheel and shapes it with highly skilled fingers

With fingers and implements the potter turns the clay into any shape he wishes. Here he is fashioning a plate

The clay article goes into the oven and becomes porcelain. Costly pottery is hand-painted, but transfers are used for decorating the cheaper kinds

Here a paper transfer is being pulled off the copper plate after printing

Now the transfer is trimmed with scissors and then is laid carefully on the porcelain vessel which becomes decorated where it leaves its facsimile

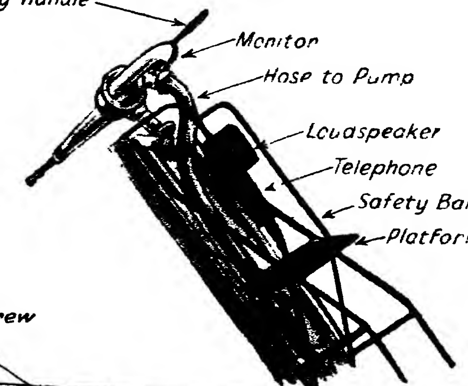
Next the article, in this case a cup, is coated with glaze by being dipped in a vessel of liquid and gets a smooth surface

The ware is then packed in containers and put in an oven to fuse the glaze to the porcelain

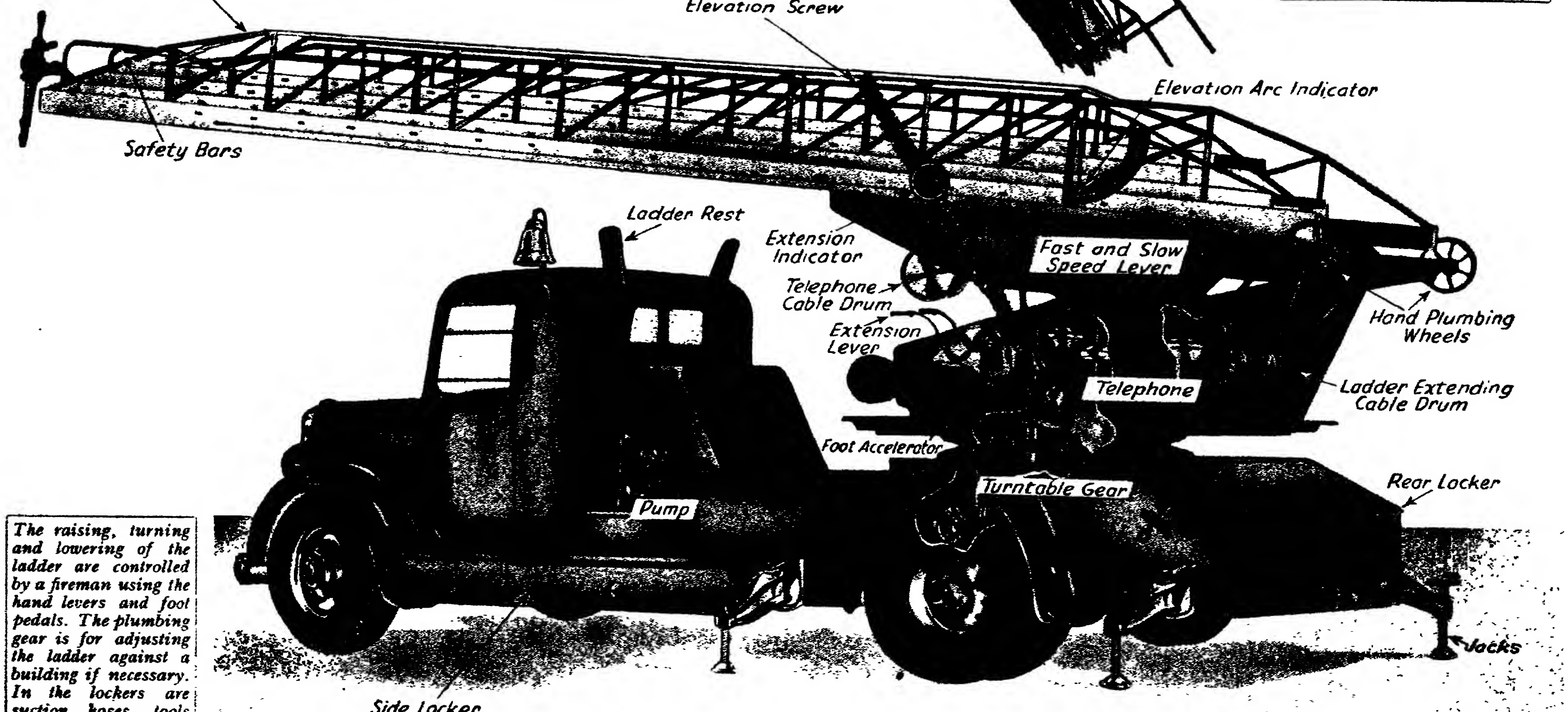
Lastly the ware goes to the enamel kiln for eight hours or more to fix permanently on the vessel the design made by the transfer

FIGHTING FIRES FROM A LADDER A HUNDRED FEET HIGH

This picture diagram shows you details of the Merryweather motor turntable used by fire brigades as a tower from which water can be poured into the centre of fires in high buildings. The ladder is in four sections and by means of gears connected to the vehicle's motor can be extended to its full height of 100 feet in 30 seconds. Before the ladder is raised, the four jacks are placed in position to provide a secure base and to prevent the ladder from tipping over. An indicator at the base of the ladder automatically shows how far the ladder is being extended, while the elevation arc-indicator shows the angle at which the ladder is being raised. The ladder is mounted on a turntable so that it can be turned in any direction before or after extension. The drawing on the opposite page shows three sections of the ladder extended



The small drawing on the left shows you what the top of the turntable ladder is like. Water, forced up by a pump behind the driving cab, is directed through the swivelled monitor on to the flames. The fireman operating the monitor stands on a platform and through the loudspeaker receives telephoned instructions from the ground. He can also speak to the officer through a telephone. The safety bars are for attaching the hooks on the monitor-operator's belt



The raising, turning and lowering of the ladder are controlled by a fireman using the hand levers and foot pedals. The plumbing gear is for adjusting the ladder against a building if necessary. In the lockers are suction hoses, tools and other equipment.

WHEN YOU CALL THE FIRE BRIGADE

Ever since men began to live in villages and towns they have run the constant risk of losing their possessions and lives by fire. Throughout thousands of years of history more buildings and cities have been destroyed by fire than by the most bitter wars. Even to-day, and in spite of highly organised fire brigades, fire destroys £14,000,000 worth of property in Great Britain every year and costs the lives of hundreds of people.

Effective methods of dealing with the fire peril in towns and cities only came about in comparatively recent times. When the Great Fire of London destroyed a large part of that city in 1666, and for long afterwards, the only equipment for fighting fires consisted of hand squirts, small buckets, and hooks for pulling down buildings to prevent a fire from spreading. Early in the 18th century came a very simple form of fire engine, which was just a hand-operated pump mounted on a cart.

In 1830 serious fire-fighting began with a London engineer's invention of a steam fire engine. Two years later the London insurance companies adopted the engine for dealing with fires in the City. But each company only put out fires at property insured with it. Later the insurance companies joined together and formed a single fire brigade, which in 1865 was taken over by the London Metropolitan Board of Works.

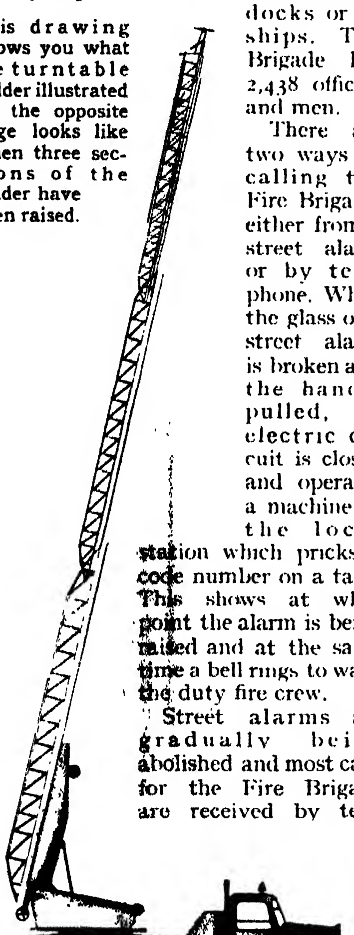
When the London County Council was formed in 1888 it took over the Metropolitan Board of Works fire brigade, and since then has been responsible for dealing with all fires in an area of 117 square miles containing some of the most congested districts in the world. Hence the organisation and equipment of the London Fire Brigade provides us with a good example of modern fire-fighting organisation and equipment.

Throughout the London Fire Brigade area there are 58 land fire-stations and three river stations, and these are so situated that within five minutes of a call from any part of the county at least one engine shall be on the scene of the fire. If the fire is a serious one, 15 engines and 100 men can be on the scene within a quarter of an hour.

Each land fire-station has at least two appliances, popularly called fire engines. One is a pump and is fitted with a standard fire pump, able to deliver 800 gallons of water a minute, a 40-foot extension ladder, hook ladders, and respirators for the crew. The other is a pump escape of the type described and illustrated on page 740. Some of the larger stations also have a turntable ladder like that shown on this and the opposite pages.

At the Brigade headquarters and a few very large stations there is a foam tender for putting out oil and chemical fires ; a canteen van for supplying meals to firemen on any call lasting more than three hours ; a breakdown lorry, on which is mounted an eight-ton crane together with hydraulic jacks, oxy-acetylene cutters, and special lifting gear for rescuing people trapped under road vehicles ; and an emergency tender carrying searchlights, asbestos gloves, electrically-insulated clothing, and a smoke-extractor which, working like a vacuum cleaner, sucks smoke and other fumes out of buildings.

Altogether the London Fire Brigade has 233 fire engines, escapes and other vehicles, 56 miles of hose, 32,000 street hydrants, and five motor-boats fitted with pumps for dealing with fires at the docks or on ships. The Brigade has 2,438 officers and men.



This drawing shows you what the turntable ladder illustrated on the opposite page looks like when three sections of the ladder have been raised.

There are two ways of calling the Fire Brigade; either from a street alarm or by telephone. When the glass of a street alarm is broken and the handle pulled, an electric circuit is closed and operates a machine in the local station which pricks a code number on a tape This shows at what point the alarm is being raised and at the same time a bell rings to warn the duty fire crew.

Street alarms are gradually being abolished and most calls for the Fire Brigade are received by telephone. A caller dialling 999 and asking for the Fire Brigade is at once connected by direct line to one of the four switchboards in the control-room at the Brigade headquarters. Beside each switchboard is a large revolving card index which gives every street, lane and mews in London, the fire station nearest any particular street, and the stations which can send reinforcements.

Immediately he has been told where the fire is, the operator who receives the call spins the revolving card index, extracts the necessary information, and then presses a button which rings an alarm in the appropriate station. While the duty fireman at the station called is being given the address of the fire by telephone, alarm bells, also started by pressing a button at headquarters, ring in every room in the station

While the driver of the engine is being given the address, the duty crew for that particular engine are sliding down poles from the upstairs quarters and mounting the appliance. The station doors automatically open and within 60 seconds of the call the engine is away.

Whenever an engine leaves its station, a signal is sent to the control-room at headquarters, where an operator plots its movements by shifting indicators on a plan of the London Fire Brigade area.

Arrived at the fire, the officer in charge of the crew takes stock of the situation, and if he decides that he can deal with it he telephones, or radios from a transmitter on the engine, a " stop " message to headquarters. This means that no more engines will be sent. On the other hand, if the officer decides he needs more help he sends a message asking for reinforcements.

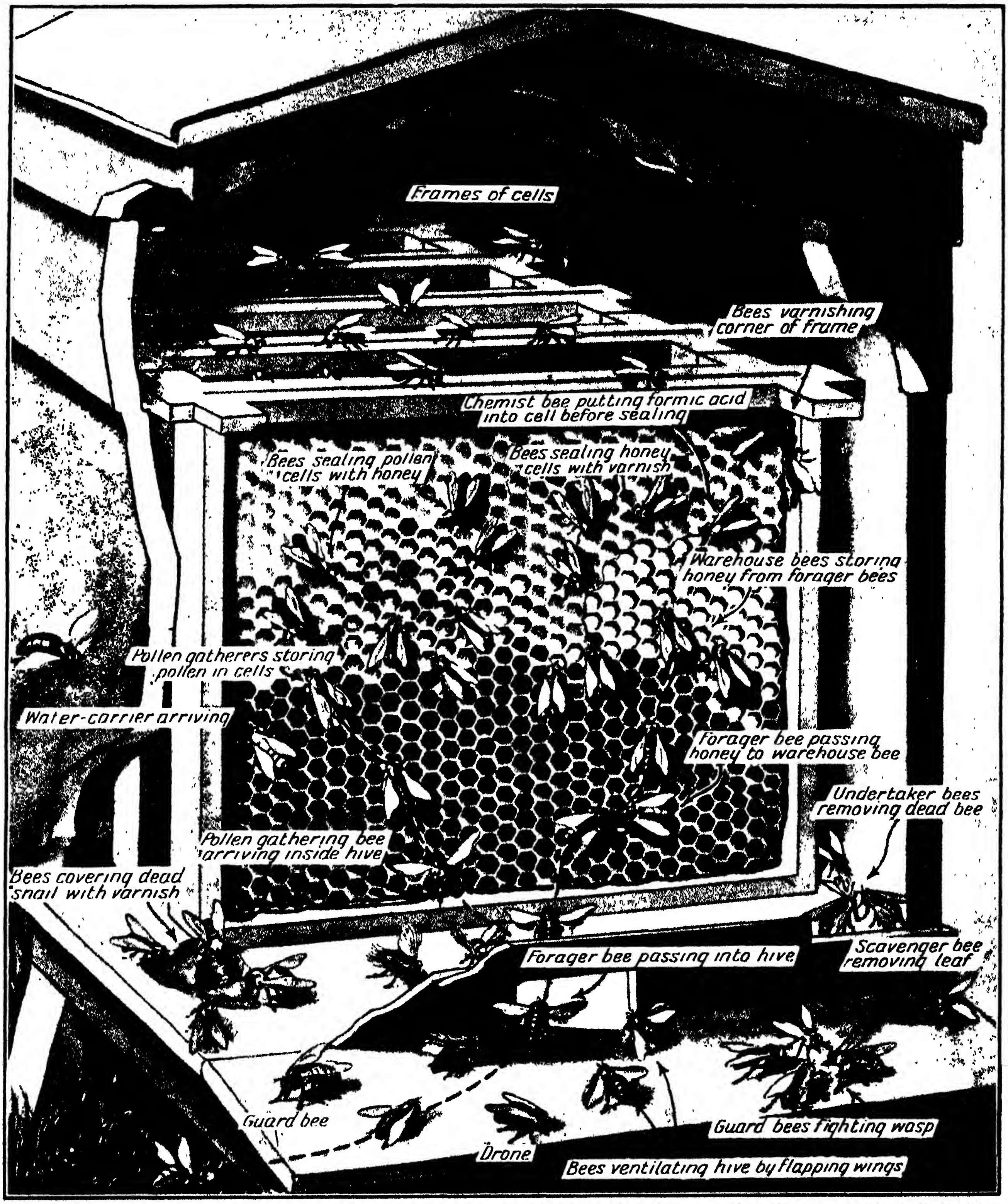
Should the fire need more than four engines, the control unit is brought into action. This is a large van fitted out as a miniature control-room, and as it travels to the fire its staff work out the plan of operations. From a large scale map of the area they find details of all hydrants near the fire and decide which ones shall be used. They may find that there are only small mains in the streets surrounding the buildings, but that there is a large main some distance away. In that event they will decide to pump from the large main and relay the flow of water through other pumps stationed between the main and the fire.

On arrival at the fire, the officers in the control unit may find the situation much more serious than they expected, so they will call for more appliances. The more engines there are at a fire, the more difficult it is to use them to the best advantage, and to prevent the different crews getting in each other's way. But by using walkie-talkie radio sets, orders can be given to scores of different fire-fighting points accurately and without delay.

Thanks to good organisation by headquarters and close teamwork between stations and crews, there are comparatively few large fires in the London Fire Brigade area. Although an average of 50 alarms are received every day by the London Fire Brigade, half are false, and six are chimneys on fire.

About 85 per cent of the fires attended by the brigade are put out by the first-aid equipment. This is a length of rubber hose through which water is pumped from a tank carried on the engine.

THE WONDERFUL LIFE INSIDE A BEEHIVE



Bees are the busiest workers in the world. Their homes are well called "hives of industry," and in this picture Mr. L. G. Goodwin shows us what goes on inside the hive. It is really the busiest of towns, with bees coming and going all day long. There are the honey gatherers, who pass their honey to warehouse keepers, who store it away in cells. Then there are the gatherers of pollen, used for feeding the bees, which is stored in hermetically sealed cells to prevent it from fermenting. There are varnishers which seal up the honey cells and fill up any cracks there may be in the hive, and also stick the comb to the frame. Other bees are chemists, and put a little formic acid into the honey before sealing, so that the honey may be preserved. While all this activity is going on other bees perform various duties, such as fanning the hive to keep it cool, guarding the hive from intruders, scavenging to remove any rubbish or dead insects that may get inside, and sealing up such creatures as snails that invade the hive. Then there are water carriers, which bring in water as required. In the midst of it all live the drones in complete idleness and luxury

THE LITTLE BUSY BEE

There is no end to the marvel of the bee and its busy life. Much of this great natural history romance has been told in earlier pages of this book (See pages 669 and 827). But there remains much more to be told, and here the remarkable story is continued

It used to be quite a regular thing for parents and teachers, when urging boys and girls to be industrious at their work or lessons, to quote Dr. Isaac Watts's rhyme :

> How doth the little busy bee
> Improve each shining hour,
> And gather honey all the day
> From every opening flower.

We have already seen in another part of this book (page 827) the astonishing industry with which the bees work when building up their community, the production of the wax, the fashioning of the cells, the care of the young, and so on. But the work for which the bee is most generally known is that of making honey from the nectar of the flowers, and it is in the gathering of this nectar and the making and storing of the honey that the insect shows its industry to greatest advantage.

Amazing Toil

When we remember that the average hive produces thirty or forty pounds of honey in a single season, and that some yield even as much as two hundred pounds, and yet that a single bee can carry in its honey bag only one-third of an ordinary drop of honey at a time, we can understand the amazing amount of toil and travel which has to be done in order that the yield of honey may be as great as it is.

We cannot have watched a hive for any length of time without being struck by the enormous activity which is going on round about the entrance. Here are bees coming and going in large numbers, those that arrive flying much less quickly than those starting off. The bees that arrive are laden with honey or pollen ; while those going off have unloaded their cargo and are so eager to get a fresh supply that many of them do not even crawl out before starting but fly straight out of the door.

Some that come out of the hive and fly off seem not at all in a hurry. They preen their wings and hesitate a moment or two before starting. These are young bees who are making their first expedition in search of nectar, and it is their first sight of daylight. No wonder they seem a little dazed.

The bees know nothing of an eight-hour day. They all work overtime, for they start out about the time that the sun's rays first strike the field or garden in the morning, and they keep hard at it till twilight falls in the evening. It is not surprising, therefore, to learn that the bees that go foraging for nectar live only two or three weeks. They literally wear themselves out with work, and when they die of exhaustion their wings are often worn away and their bodies covered with wounds.

But they do not complain ; they do not consider that they have earned a pension and try to live on at the expense of the other bees ; they fly or crawl away to some retired spot and there die. The other bees do not even have the trouble of burying them.

Other bees that we see coming and going less rapidly than the foragers who seek nectar have a different business. They are pollen gatherers. But

A bee entering a balsam blossom in its search for nectar

if we are very observant we shall notice that certain bees, while flapping their wings very vigorously, do not fly away at all ; they stand round the entrance to the hive, their heads pointing to the door, and go on moving their wings so rapidly that they become invisible, just as the propeller of an aeroplane is invisible when it is revolving rapidly. What can these bees be doing ?

Their work is to ventilate the hive and prevent the inside getting too warm. The movement of their wings draws out the warm air from the hive, and just inside the door there are other bees acting in the same way with their heads looking also towards the opening, which are drawing in cool air from the outside.

If the sun is hot and the hive gets warmer still more bees take up the work of ventilation. When a bee gets exhausted it stands aside and another bee at once takes its place and carries on the good work. The fanning goes on on hot summer nights as well as by day, and so strong is the draught of air made by the bees' wings that it will even blow out a candle flame if this is placed near the door.

The most important workers of the hive are the gatherers of nectar, a liquid secreted by flowers of various kinds and containing much cane sugar. When the bee reaches a flower she settles on it and then pokes her tongue or proboscis down to the nectar, and by means of a spoon at the tip collects a tiny drop. The tongue can be drawn in or extended at will. The nectar is then sucked up a tube which runs the whole length of the tongue and passes into the honey sac. The tongue is then extended to get another drop of honey, till at last the sac is filled.

How the Bee Makes Honey

As explained on page 672, the honey passes from the sac into the stomach and then returns, being strained of impurities on the way. When the sac is filled the bee flies back to the hive, and on the way the nectar is changed into honey, the cane sugar by the addition of juices from certain glands being transformed into what is known as grape sugar, which is easily digestible by human beings as well as by bees. This change must be remembered, for the bee is not simply a honey gatherer—it is a nectar gatherer and a manufacturer of honey from nectar.

On arriving at the hive the bee passes straight in, being allowed to enter by certain guard bees who are on the watch for pirates and burglars, but who recognise their own friends immediately. If a strange bee tries to enter or a wasp, a great fight takes place and the robber is invariably killed.

Arriving inside the hive, she is met by another worker bee who does the warehousing. The forager passes the honey made from the nectar out of her tongue to the warehouse bee, who swallows it, and this bee then goes up to a vacant cell and, poking her tongue inside, empties out the honey that has been handed to her. The forager bee, directly she has been relieved of her load, passes out of the hive again and goes off to search for fresh supplies. Often she will travel as far as three or four miles to find suitable flowers, but she always finds her way directly back to the hive. When we want to describe a straight line of travel we generally speak of a bee line.

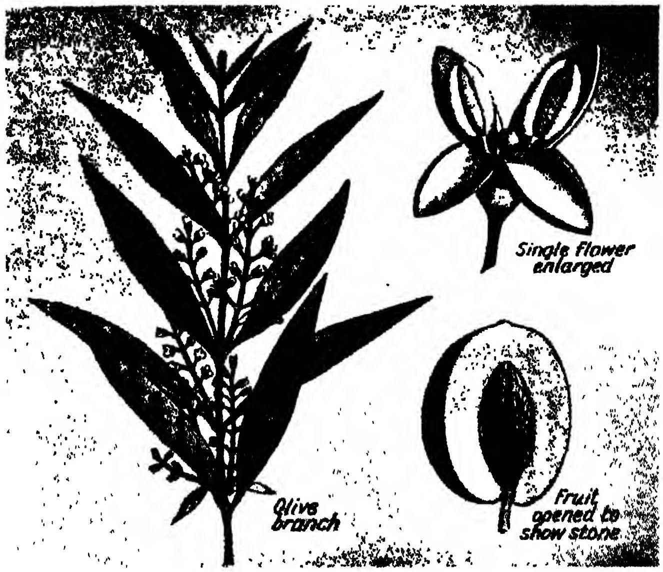
How the bee finds her way back to the hive no one can say.

THE OLIVE TREE AND ITS USEFUL FRUIT

The olive is one of the oldest of cultivated plants, and is valued chiefly because of the oil which its fruit yields. The pulp is neither sour nor sweet like that of most other fruits, but is very rich in oil, and this is extracted by pressure.

In olden times in the Mediterranean countries an olive yard like a vineyard was regarded as a great possession, and we find constant references to the olive in the Bible.

The high estimation in which it was held is proved by such expressions as that which speaks of "children like olive plants round thy table," and in the Book of Judges we find a fable which tells how the trees, wanting a king to reign over them, said unto the olive tree, "Reign thou over us." One of the greatest disasters that could overtake the people of Palestine was for their vineyards, fig trees and olive trees to be destroyed by insect pests, as described by the prophet Amos.



A spray of olive in blossom and, on the right, a single flower enlarged and a fruit cut open to show the stone

The olive is a low-branching evergreen tree, which attains a height of from 20 to 30 feet, and lives to a great age, and it will grow in soil made chiefly of ashes, as it does on the slopes of Vesuvius and Etna. The leaves are dark green or bluish, and the cream-coloured fragrant flowers develop into a purplish-black fruit which has a stone inside. Like the plum, cherry, apricot and peach, the fruit is known to botanists as a drupe, a name that comes from the Latin word for an unripe olive.

The olive is probably a native of the Mediterranean countries, but it is now grown in large quantities in Africa, Australia and America.

As soon as the olives begin to drop from a branch when it is shaken they are ready for picking, if they are wanted for pickling. For this purpose they are generally gathered hard and green.

If they are wanted for their oil, they are left on the tree until they are ripe, but not till they become soft. There is a great art in gathering the olives at the right moment, for if they are picked too early the oil extracted from them is bitter, and if they are gathered too late it is rancid. The olive picking is done by hand.

The fresh fruit, whether green or ripe, is not pleasant to the taste in the natural state. For pickling, the green olives are soaked in weak lye, to take out the bitter taste, and then rinsed and soaked in brine with certain flavourings. Sometimes the ripe fruit is pickled, but this is a much more difficult task.

In ancient times the method of pressing the oil from the fruit was by treading it with the foot, just as grapes were pressed, and even to-day the pressing of the oil is carried out in this way in the East.

In European countries and in Australia and America, however, a press something like a cider press is used, and where the oil is produced on a very large scale still more elaborate presses do the work.

The olives are first dried slightly in the Sun or by artificial heat as they can then be handled more easily. They are then crushed to break the cells that contain the oil, and are formed into blocks called cheeses about a yard square and three inches thick. These are packed in linen and the cheeses, piled one upon another, are then gently pressed so that the oil may flow out.

The best oil is that which comes out first, and there are two other pressings, the oil which is obtained at the third operation being used only for lighting or soap-making. The oil as it flows settles in vats and is allowed to flow from one vat into another, impurities settling in each vat. At last a clear yellow oil is obtained, ready for packing and sealing in bottles.

Olive oil is of great food value, but it is often adulterated with the oil obtained from peanuts, cotton seed and other plants. These are equally wholesome and of practically the same chemical composition, but they are inferior in flavour to good olive oil.

The olive will grow in any hot, dry climate on irrigated land, but it does not like a humid atmosphere and so will not grow and thrive in the Tropics.


A spray of olive with berries ready for picking

A SALMON LEAPS TO THE TOP OF A CASCADE

The salmon is a strange fish. It is really a sea fish, but it ascends the rivers and streams at certain seasons in order to deposit its eggs on gravel, where in due course they hatch out and become young fish. After a certain time they descend to the sea, some in their first year, some in the second, and some in the third. After they have remained in the sea for a time they go back up the river. Meanwhile, the parent salmon, having spawned, go back to the sea in such a miserable condition that many die on the way. But once in the sea they soon recover and again return to the rivers. Salmon grow to a length of as much as five feet, and sometimes turn the scale at sixty pounds. In travelling up the rivers the salmon often journey for hundreds of miles, and they leap over weirs and waterfalls, jumping six feet or more at a time, like the fish in the photograph, which is jumping the Struan Falls, in Perthshire

THE MAZE OR LABYRINTH OF GROWING TREES

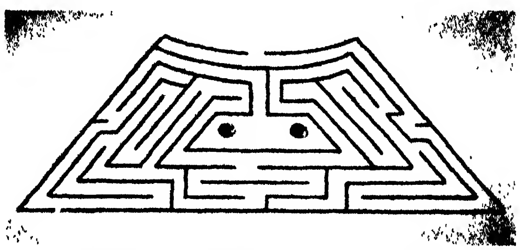
The vitality of some trees and bushes is astonishing. They may be cut and clipped and lopped and bent, and yet flourish and grow quite healthily.

From Queen Elizabeth's reign right down to the eighteenth century it was a common practice to cut the yew, the box and other trees into all sorts of fantastic shapes, such as crowing cocks, and so on. It is still the practice to cut these and other evergreen plants when they are grown in thick hedges to a rectangular shape.

Another queer custom during the period referred to was the planting and growing of these trees in the form of a labyrinth or maze. The path from the entrance to the centre was by devious ways, being constantly cut off so that the visitor had to retrace his steps and take fresh turnings. Several of these mazes still exist, the most famous being that at Hampton Court, a photograph of which is shown on this page, together with its design. It was laid out about the year 1700, and consisted originally of hornbeams, which have since been replaced by hollies and yews.

The design of these garden mazes was not haphazard. They were always laid out on some principle so that the owner might always know how to find his way in or out. The maze at Hampton Court, for example, is laid out in such a way that to get to the centre from the entrance one must keep the right hand in contact with the hedge; that is, if one on entering touches the hedge with the right hand and does not take it off but follows the hedge round in this way, one will eventually get to the centre.

These mazes were very popular at the time when geometrical gardening was in fashion, all the beds being laid out very precisely in circles, squares, triangles, and so on. The idea of a maze was originally obtained from the story of the Cretan labyrinth built by Daedalus for King Minos, in which to house the Minotaur.



The design of the Hampton Court maze

In the days when mazes were fashionable, and so many of the large mansions in England had one in the garden, the designs were often very intricate, much more so than is the case with the Hampton Court maze of to-day. In some cases there were a considerable number of entrances, only one of which enabled the visitor to reach the centre of the maze. All the others ended in blind alleys.

Without the key of a maze a person may by perseverence or chance reach the centre, but it is sometimes more difficult to get out than to get in. Many a visitor to the Hampton Court maze has proved this and has been able to escape only with the help and direction of a keeper.

Perhaps the most famous of the garden mazes in history or literature is that of Fair Rosamond, the friend of King Henry II of England. She was the daughter of Lord Clifford, and, according to the legend, lived in a retreat in the centre of a maze or labyrinth at Woodstock Park, Oxfordshire. Queen Eleanor, the wife of Henry II, found her way through the maze by means of a ball of silk thread, which caught in King Henry's spur and was unravelled as he made his way from the entrance to the centre of the maze.

By following this thread Queen Eleanor reached the place where Fair Rosamond lived, and as the legend says, had her put to death. According to another version this labyrinth or maze was constructed underground.

It is curious how the thread method of finding one's way in or out has lived through history. The classical story of the Minotaur says that the only method of finding the way out of the Cretan labyrinth was by a skein of thread.

A photograph of part of the Hampton Court maze showing a number of visitors trying to find their way to the centre

BRITAIN PUTS AN END TO SLAVERY

Every British boy and girl and every grown-up Briton, too, should know the wonderful story of how England took the lead in abolishing slavery and the slave trade and set a new standard for the world in the treatment of the negro races. Here is the story of this Great Crusade which the historian William Lecky describes as "among the three or four perfectly virtuous pages comprised in the history of nations"

FROM the time that man first appeared on the Earth right down to the present day he has, somewhere or other, enslaved his fellows. The so-called Christian nations have been as guilty as others, and it is a strange fact that the last Christian country to abolish slavery only did so after the fighting of a long and bitter war.

It was in the childhood of living people that slavery was finally ended in the United States by the proclamation of Abraham Lincoln on January 1st, 1863. Many ministers of the gospel in that country had proved from the Bible to their own satisfaction and that of the slave owners that slavery was an excellent institution, ordained by God for the benefit of both the masters and the slaves.

The much-lauded Declaration of Independence, regarded by Americans almost as a sacred and inspired document, declared that: "We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, and that among these are life, liberty and the pursuit of happiness."

Yet, when Lincoln made his great proclamation, there were more than 4,000,000 black or half-black people held in the basest servitude in the United States.

No maritime or colonising nation can plead innocence of the terrible Slave Trade, perhaps the most dreadful crime that can be laid to the charge of humanity. No form of lying or treachery or cruelty was too base to be employed in the capture or kidnapping of African negroes for the slave markets of America, and the transport of these unfortunate victims across the Atlantic was accompanied by horrors that can be equalled nowhere else in history.

We may well be ashamed that the English took a leading part in this vile trade, but perhaps it is some compensation that England also took a lead in abolishing not only the Slave Trade but slavery itself. Here we have linked together the darkest and the brightest passages in England's story.

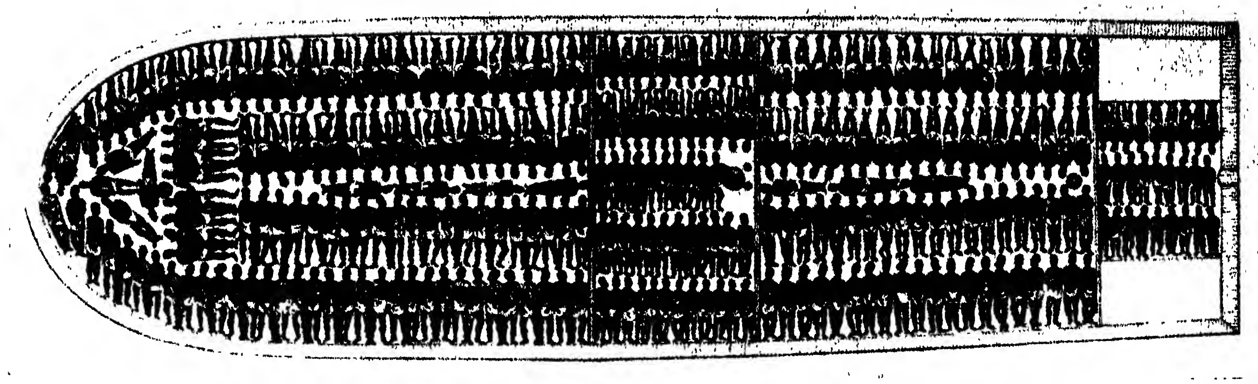
After the Spaniards had discovered America they enslaved the native peoples to work in the mines and the fields, and so terrible were the conditions of their labour that these unfortunate people died like flies. In some of the islands they were actually exterminated, and as the Spanish conquerors were not the kind of people to work themselves, they found it necessary to import negro slaves from the Old World. It was a Spanish bishop who first suggested this solution of the labour problem in the New World.

The kidnapping and transport of the blacks was a profitable business, and Sir John Hawkins, who later did such good service in defeating the Spanish Armada, decided that England should have her part in the profitable trade. He has the miserable reputation of being the first Englishman to traffic in slaves.

In 1562 he formed a company in London, fitted out three ships, captured 300 negroes at Sierra Leone and carried them off to San Domingo.

In this nefarious traffic the strangest things happened. When Hawkins planned a second slave raiding expedition he obtained the approval of Queen Elizabeth, who lent him a large ship called the *Jesus*, in which to make the venture, and when with this vessel and three smaller ones he sailed on his expedition he ended his order

Slaves being shipped on the coast of Africa. From the painting by George Morland



How slaves were packed on board ship by Act of Parliament for transport from Africa to America

to the crews with the words: "Serve God daily, love one another, preserve your victuals, beware of fire and keep good company."

His idea of carrying out these pious and admirable sentiments was to go "every day on shore to take the inhabitants with burning and spoiling their towns."

When after being becalmed a breeze blew up and Hawkins and his men could bear down once more on the homes of the black people, he wrote in thankfulness: "But the mighty God who never suffereth His elect to perish, sent us the breeze."

Such was the queer mixture of piety and fraud, of kindly sentiment and cruel practice, that characterised the Slave Traders right through their history.

A Dreadful Privilege

After Marlborough's great victories on the continent of Europe came the Peace of Utrecht in 1712, and among the English gains, as announced personally to the House of Lords by Queen Anne, was the following: "Spain will yield to us the fortress of Gibraltar, the whole island of Minorca, and the monopoly in the trade of negroes for thirty years."

When there was some objection on the part of Holland to the enjoyment of this monopoly by Britain, Bolingbroke, the great English statesman, wrote: "Does it not make your blood curdle in your veins to hear it solemnly contended in Holland whether Britain shall enjoy the asiento?" The asiento was the slave contract of the Treaty.

But even in those days there were Englishmen of finer thought. Alexander Pope, writing of the untutored native, said:

> Yet simple Nature to his hope has given
> Behind the cloud-topt hill a humble heaven;
> Some safer world in depths of woods embraced,
> Some happier island in the watery waste,
> Where slaves once more their native land behold,
> No fiends torment, no Christians thirst for gold.

The dimensions of the Slave Trade may be gathered from the fact that it was estimated that by 1780 nine million negroes had been exported from Africa to North and South America, and that in the century which preceded the abolition of the Slave Trade by the United States in 1808 the English alone had imported into America nearly three million negroes, while at least a quarter of a million had been thrown overboard during the voyage across the Atlantic. About this throwing overboard of the slaves something will be said later.

The British Slave Trade seems to have reached its height just before the American War of Independence. It was carried on chiefly by ships from Liverpool with a few from London, Bristol and Lancaster. Altogether there were 192 slave ships sailing from these ports and in them space was allotted for the transport of 47,146 negroes.

The development of the American Colonies increased the demand for slaves, and at least 58,000 a year had to be imported to keep up the stock.

The practice of the slave traders was to land on the coast of Africa, set fire to a village by night, and capture the inhabitants as they tried to escape. Then the negroes were manacled and taken on board the slave ships, where they were packed in the hold as tightly as cases of whisky or barrels of rum are packed in a smuggling vessel to-day. A ship the size of a small coasting schooner would carry six or seven hundred negroes laid on their sides like spoons in a case, the knees of one fitting into the hamstrings of his neighbour. They could neither sit properly nor stand upright.

Packed Like Herrings

One historian tells us that the negroes "were chained to each other hand and foot and stowed so close that they were not allowed above a foot and a half for each in breadth. Thus crammed together like herrings in a barrel they contracted putrid and fatal disorders, so that they who came to inspect them in the morning had occasionally to pick dead slaves out of their rows and to unchain their carcasses from the bodies of their wretched fellow sufferers, to whom they had been fastened."

If the slaves made any trouble on the voyage, the lash and boiling water seem to have been the remedies adopted to restore order.

It has been well said that so much wretchedness was never condensed in so little room as in the slave ships.

Even the British sailors employed in the traffic perished in large numbers from the contagion on board. More seamen died in the Slave Trade in one year than in the whole remaining trade of England in two.

Appalling Conditions

The mortality among the poor negroes carried across the Atlantic was appalling. Many died before they sailed from Africa. Then 25 out of every 200 were lost during their passage. At Jamaica or other destination nine died out of every 200, while in the harbours or before the sale, and one-third more during the "seasoning" period, that is, before the slaves actually settled down to regular work. Altogether, not more than fifty lived to be effective labourers out of every hundred shipped from Africa.

But apart from the terrible deaths from disease owing to overcrowding, there was a mortality even more sinister. When the captain of a ship carrying a large complement of slaves found on approaching port that many of the slaves were sick and likely to die, he would have them brought up on deck and pitched overboard while still fettered with irons. This was done in order to be able to claim insurance money from the underwriters. The slaves were often insured for as much as £30 apiece, but if they died a natural death the loss fell on their owners. On the other hand, if it could be proved that for the safety of the ship they had been thrown into the sea, the claim upon the insurers held good.

A captain, therefore, finding that a large number of his slaves was likely to die before reaching their destination, would sometimes pretend that the ship had been becalmed and that there was a shortage of water. He claimed that he had a perfect right to throw the slaves overboard in order to save the water for the white crew and the slaves remaining on board. Unless his

allegation of the water falling short could be disproved, the insurers had to pay. There are instances on record of such cases being contested in the Courts and the British juries finding in favour of the slave traders.

In a book like this the worst horrors of the Slave Trade cannot be described, but sufficient has been said to show how terrible was the dreadful business. It seems almost incredible that it was only at the end of the eighteenth century that any number of influential Christian men began to concern themselves about the Slave Trade. It seems even more unbelievable that when the facts were put before the British public it took years of agitation before the national conscience could be stirred up sufficiently to abolish the trade.

Human Chattels

For example, when a case was made public of a captain throwing 122 sick slaves overboard to get the insurance money, the Solicitor-General of the day said indignantly: "What is all this vast declamation of human people being thrown overboard? The question after all is: Was it voluntary, or an act of necessity? This is a case of chattels or goods. It is really so—it is the case of throwing over goods; for to this purpose and the purpose of the insurance they are goods and property; whether right or wrong, we have nothing to do with it." Thereupon the Admiralty, which had been petitioned, took no further steps in the matter.

So-called Christian people engaged in the trade and shared the profits. Even the bills of lading mentioned God's name and prayed for His blessing on the enterprise. "Shipped by the grace of God in good order and well-conditioned," begins one of these documents, which specifies so many slaves, "marked and numbered," that is, branded with a hot iron, and it ends up "And so God send the good ship to her desired port in safety. Amen."

In some of the churches prayers were offered for a safe voyage, and many a churchgoer benefited directly or indirectly by the Slave Trade, for if he did not actually have a financial interest in the shipping of the slaves, he at any rate often drew dividends from the plantations where the negroes worked.

It was a few Quakers who first began to protest against the infamous trade which left such a stain on England's fair name, but for a long time nothing practical was done that in any sense roused public opinion.

In the year 1765 an incident occurred in London which may almost be regarded as the beginning of the movement to abolish the Slave Trade. Many West Indian merchants when they came to London used to bring their black servants with them. These negroes were, of course, slaves, and sometimes they would try to escape from their masters. The newspapers of the day contained advertisements offering rewards for the capture of such fugitives.

One morning in 1763 Granville Sharp, the son of the Archdeacon of Northumberland and grandson of the Archbishop of York, who held an appointment in the Ordnance Office, was visiting his brother, a doctor, in Mincing Lane, when he saw a negro dragging himself slowly along the street, evidently very ill. He questioned the man, and found that his name was Jonathan Strong, and that he had been the slave of a Barbados lawyer named David Lisle. His master had brought him to London, and one day beaten him brutally over the head with a pistol, and then turned him into the street nearly blind.

Granville Sharp one morning saw a negro dragging himself slowly along a London street, evidently very ill. He questioned the man and found he was a slave

The Sharp brothers took the poor fellow to St. Bartholomew's Hospital, where he remained for some time between life and death, and was only healed after four months of treatment. The Sharps found him employment, and everything went well for two years.

Then one day in 1765 Lisle, walking in the streets of London, suddenly saw Strong looking well and happy, and had him arrested. Granville at once applied to the Lord Mayor for a summons against Lisle for detaining Strong without a warrant. It then appeared that Strong had been sold by his brutal owner to a Jamaica planter, but the purchaser refused to pay until the negro was safely on board a particular ship, the captain of which had instructions to take him across the Atlantic.

The Lord Mayor gave his decision that "the lad had not stolen anything and was not guilty of any offence, and was therefore at liberty to go where he pleased."

The captain of the ship, however, seized the negro by the arm to lead him off to the vessel, whereupon Sharp said, "Sir, I charge you for an assault." The captain, wanting no trouble, let go, and Strong followed his defender home, no one daring to touch him

Studying the Law

Granville Sharp consulted an eminent solicitor, who told him that his action could not be defended So Sharp himself began to study the law concerning the liberty of the person As a result of this study he wrote: "There is no law to justify a claim to the servitude of any man in England, native or alien, unless he is indentured for a term of years with his own consent An Act was passed in the 1st Edward VI by which vagabonds were made slaves, but was repealed the 3rd or 4th of the same reign And, besides, the word 'slaves' or anything that can justify the enslaving of others is not to be found, God be thanked, in any other law or statute whatever, at least that I am able to find out."

He published his conclusions, but David Lisle brought an action and obtained judgment against Sharp with treble costs.

The case of Jonathan Strong had drawn attention to the matter of fugitive slaves in England, and when a little later James Somerset, a negro from Virginia who had been brought over to London and then left his master, was seized and sold into slavery, the matter was contested in the court of King's Bench.

The case came before Lord Chief Justice Mansfield, and the counsel who opened the case said that he intended to maintain the proposition "that no man at this day is or can be a slave in England," while another counsel

who closed the proceedings on behalf of Somerset expressed the assurance that when judgment was given slave-holders would know once and for all "that when they introduced a slave into this country as a slave this air is too free for him to breathe in."

There was a long hearing, and then the Lord Chief Justice delivered his memorable judgment: "The question is," said he, "whether the captain has returned a sufficient case for the detainer of Somerset. The case returned is that he had kept him by order of his master with an intent to send him abroad to Jamaica, there to be sold. So high an act of dominion must derive its force from the law of the country, and to be justified here must be justified by the laws of England. Slavery has been different in different ages and States. The exercise of the power of a master over his slave must be supported by the laws of particular countries, but no foreigner can in England claim a right over a man; such a claim is not known to the laws of England."

Free England

Lord Mansfield concluded by declaring that the claim of slavery never could be supported. Such power never was in use in England, or acknowledged by the law, and he ordered the man to be discharged. "As soon as a negro comes into England," he said, "he becomes free."

It was a momentous decision, but the most astonishing thing about it is that such a fact was not publicly established till the year 1772.

William Cowper, the poet, in his "Task" dealt with the matter in fine language when he wrote:

> Slaves cannot breathe in England; if their lungs
> Receive our air, that moment they are free;
> They touch our country, and their shackles fall.
> That is noble, and bespeaks a nation proud
> And jealous of the blessing. Spread it, then,
> And let it circulate through every vein
> Of all your Empire; that where Britain's power
> Is felt, mankind may feel her mercy, too.

Four years after Lord Mansfield's great decision a Member of Parliament, David Hartley, moved in the House of Commons a resolution that "the Slave Trade was contrary to the laws of God and the rights of men." It seems incredible that this motion was lost, but the legislators were not yet sufficiently educated in moral values to believe the statement true.

The next great step in the abolition of the Slave Trade was taken in 1785, when Dr Peckard, the Vice-Chancellor of the University of Cambridge, announced as the subject for the Latin disputation of the Senior Bachelors the question "Is it lawful to make slaves of others against their will?"

Among those who competed was Thomas Clarkson, the son of a clergyman, who won the first prize, but was so overwhelmed with horror at the facts he had discovered that his success gave him no pleasure.

We are told that as he journeyed to London after receiving the prize his mind was so filled with the thoughts of the sufferings of the slaves that he had to halt and sit by the roadside, holding his horse by the bridle. He determined then and there, although he knew nothing of what others were doing, to fight this great evil till it was abolished.

Clarkson after receiving his prize at Cambridge was returning to London when his mind became so filled with thoughts of the suffering slaves that he had to halt and sit by the roadside

Clarkson published his essay, and gradually as the terrible facts became known, a number of good men came together to unite in a movement for the abolition of the Slave Trade.

One of these was young William Wilberforce, the son of a wealthy Hull merchant, who while yet a boy wrote a letter to a newspaper against "the odious traffic in human flesh." When he grew up he entered Parliament, and became so friendly with William Pitt, the Prime Minister, that the two were almost like brothers.

One day the two young men were sitting at the root of an old tree in Holwood just above the steep descent into the valley of Keston in Kent, discussing the Slave Trade, when, urged by Pitt, Wilberforce resolved to give notice in the House of Commons of his intention to bring forward a motion for the total abolition of the Slave Trade.

This was in 1788, and having put his hand to the plough Wilberforce never turned back, but supported by Clarkson and the Quakers he carried on the struggle for nineteen years, till at last in 1807 his efforts were crowned with victory and the Slave Trade was abolished by the English Parliament.

The astounding thing is that with all the facts laid before the public it took so long to bring the conscience of England to the condition of saying that the vile traffic should cease, so far as Britons were concerned.

As can be imagined, it was a terrific fight. First of all an attempt was made to bring about some amelioration of the conditions of the voyage from Africa to America. It was shown that every slave, no matter what his size might be, was allowed only five feet six inches in length and sixteen inches in breadth to lie down in. Between the floor and the ceiling platforms or broad forms were placed on which slaves also were packed like sardines. The height from the floor to the ceiling did not exceed five feet eight inches, and in many cases it was not more than four feet.

Horrible Treatment

The men were chained two-and-two together by their hands and feet, and were also fastened by ring bolts to the deck. They spent fifteen or sixteen hours below deck out of every twenty-four, and were brought up in gangs for an airing for a few hours.

When it was desired to give a little more space to the poor slaves there was a heated dispute and the House of Lords threw out the Bill twice. The third time it was passed.

It is satisfactory to know that Wilberforce was supported in his attempts to abolish the trade by such men as Burke, Pitt and Fox. When, as a preliminary measure, attempts were made to regulate the traffic, Fox said, "With regard to the regulation of the Slave Trade, I know of no such thing as the regulation of robbery and murder."

It is also interesting to know that the very last letter that John Wesley wrote was one on February 24th, 1791, addressed to Wilberforce, in which he said:

"My dear Sir,—Unless Divine power has raised you up to be as *Athanasius contra mundum*, I see not how you can go through your glorious enterprise, in opposing that execrable villainy which is the scandal of religion, of England,

and of human nature. Unless God has raised you up for this very thing, you will be worn out by the opposition of men and devils; but if God be for you, who can be against you? Are all of them together stronger than God? Oh! be not weary of well-doing. Go in the name of God and in the power of His might till even American slavery, the vilest that ever saw the sun, shall vanish away before it. That He who had guided you from your youth up may continue to strengthen you in this and all things, is the prayer of, dear Sir, your affectionate servant,—JOHN WESLEY."

When the House of Commons was finally induced to resolve that the trade should cease on January 1st, 1769, a similar motion brought forward in the Lords was postponed in order that further witnesses might be examined. Even a Bill brought forward in the Commons to abolish that part of the trade by which British merchants supplied foreign settlements with slaves was lost, and when later on it was carried in the Commons it was defeated in the Lords.

Progress Despite Setbacks

All the time Wilberforce worked like a Trojan. When after several rebuffs he brought his measure for abolition once more before the House of Commons in 1805 and lost the second reading of the Bill by a small margin, he wrote: "Great canvassing of our enemies and several of our friends absent through forgetfulness or accident or engagements preferred from lukewarmness." He had the matter of the slaves so much at heart that it interfered with his rest. "I could not sleep," he wrote in his Journal, "after first waking at night. The poor blacks rushed into my mind, and the guilt of our wicked land."

But despite all setbacks, steady progress was made. On June 10th, 1806, Fox brought forward a resolution that "effectual measures should be taken for the abolition of the African Slave Trade in such a manner and at such a period as should be deemed advisable." This was carried by a large majority and a similar resolution was passed by the House of Lords.

Then a Bill was passed through both Houses forbidding the employment of any new vessels in the trade. Finally, in 1807, a Bill was passed enacting that no vessel should clear out for slaves from any port within the British Dominions after May 1st, 1807, and that no slaves should be landed in the British Colonies after March 1st, 1808.

But although the nefarious Slave Trade was thus made illegal, so far as Englishmen were concerned, slavery still existed in the British Colonies, and in other parts, and slaves were wanted to replace the many deaths among the unfortunate negroes on the American and West Indian plantations.

It therefore became very profitable to kidnap large numbers on the African coast and smuggle them across the Atlantic.

To make a slave-running expedition pay, the slaves had to be captured wholesale and packed in the hold more tightly than ever. Naturally, the mortality was terrible. One small ship carrying 747 lost 136 on its voyage. The condition of the ships can be better imagined than described. A British naval officer engaged in suppressing the dreadful traffic declared that one could positively smell a slave ship five miles down wind.

William Wilberforce when he began his great fight against the slave trade

Wilberforce in old age, after he had seen the triumph of his efforts

It is not surprising that the men who could engage in such a trade became first callous, then cruel, and finally so lost to all sense of decency and mercy as to be capable of anything. They feared neither God nor man nor devil. Although we know this, yet still it seems almost impossible to believe that a certain recorded incident really happened, and that within the lifetime of the parents of people living to-day, were it not thoroughly well authenticated.

British warships, of course, used to sail the seas watching for these slaving vessels, and when they saw one they would pursue it and, if possible, take possession. The penalties of being caught were heavy, but the law, made by men who had never realised the depths of crime and wickedness to which cruel and desperate villains would descend, declared that the ship could only be confiscated if the negroes were actually found on board.

The result of this law was that many a captain of a slaver has thrown his negroes overboard before capture, so that the necessary evidence against him might be wanting.

But for sheer cruelty and callous wickedness Captain Homans of the brig *Brillante* exceeded all his contemporaries.

He was carrying six hundred negroes to America when he suddenly saw four warships approaching from four different directions. To escape them was impossible, and it was quite certain the officers would board his vessel.

A Terrible Deed

When the warships were first seen it was late afternoon, and soon afterwards the breeze dropped, which delayed the vessels in their approach. Darkness fell before the first warship was near enough to fire across the bows of the slaver as a signal to stop.

Captain Homans did not hesitate for a moment. No qualms of conscience worried him, no feelings of humanity lingered in his soul. He gave orders for the largest anchor on the ship to be made ready for dropping. The chain cable which held it was hauled out through the hawse-pipe and stretched round the ship on the outside of the rail.

Then under cover of the darkness the slaves were brought up from below—six hundred of them, all living men of flesh and blood—and placed round the rail of the ship in piles. Each man or group of men was bound to the anchor-chain by strong ropes fastened to the manacles.

This had hardly been done when the splashing of oars was heard, and it was realised on the *Brillante* that the boats from the warships were approaching.

Captain Homans immediately set about removing the evidence from his vessel. He gave orders to his men to cast loose the anchor. There was a grinding sound as the chain followed the anchor, shrieks and groans rang out, and then a prolonged wail that was soon silenced, and in a moment or two six hundred living negroes had gone overboard and sunk in the black waves.

The cries of the slaves were heard by the sailors approaching in the boats, and they knew what it meant. The horror of it appalled them. Tough as they were, the wickedness of the slaver captain made them fear. For a moment they hesitated, then rowed on and boarded the brig.

The odour of the slaves, an odour which could never be mistaken, clung to the vessel in every part, some of their manacles were lying about, great pans contained the food prepared for their next meal, but not a single slave was on board, and so no legal evidence of the captain's crime existed. Captain Homans jeered in the faces of the boarding officers, and he went scot-free with his vessel.

Such was the slave trade of less than a hundred years ago, for the smuggling of negroes across the Atlantic went on till after 1850.

The friends of the slaves in England now began to work for the abolition of slavery itself throughout the British Dominions, and here they had even a fiercer fight than in the campaign to end the Slave Trade. They began to let the public know the conditions of the slaves on the plantations.

Brutal Laws

Under British law, in some Colonies a runaway slave absent for a month might have his ears cut off, or be hamstrung or branded. Any one might kill a runaway slave, who had been proclaimed, and in Jamaica the slave might have one foot cut off after thirty days' absence.

Another great and good man now came forward to continue the work of Wilberforce—Thomas Fowell Buxton. Wilberforce had written to Buxton asking him to take up the anti-slavery cause, pleading his own growing infirmities as the reason for the need of a new leader.

Buxton agreed, and with other men like-minded, including Zachary Macaulay, father of Lord Macaulay, began the campaign.

The first step was a petition to Parliament in 1823 from the Society of Friends, presented by Wilberforce. A few weeks later Buxton moved a resolution "that the state of slavery is repugnant to the principles of the British Constitution, and of the Christian religion, and that it ought to be gradually abolished throughout the British Colonies with as much expedition as may be found consistent with a due regard to the well-being of the parties concerned."

The Government dared not openly oppose such a resolution, but suggested that any plan of change should in the first place be submitted to the Colonial legislatures, and circular letters were sent to these bodies with the Government's recommendations, which included the abolition of corporal punishment for females, and the prohibition of the separation of families. The use of the driving whip was also to end.

But the planters rose in indignation at any such suggestion, and the Colonial legislatures declined to act.

Space does not permit of the whole story being told of this vigorous campaign to end an abomination. The anti-slavery leaders were slandered to throw discredit on them and their cause. Wilberforce was described as a man who beat his own wife, and it was falsely declared that Buxton had himself held slaves, the time at which this was supposed to have taken place being when he was a child of tender years.

By this time, although Parliament was supine, public opinion throughout the country was getting thoroughly roused. A crowded meeting was held in Freemasons' Hall, London, in 1830, when Wilberforce took the chair for the last time, and Clarkson was also present. Buxton moved the resolution "that no proper or practical means should be left unattempted for effecting at the earliest period the entire abolition of slavery throughout the British Dominions."

Sitting at the root of an old tree above the valley of Keston in Kent Pitt and Wilberforce discussed the slave trade, and Wilberforce resolved to bring forward a motion in the House of Commons for its abolition

After several speeches, a magistrate rose and said, amid general applause: "The time is come when we should speak out and speak boldly our determination that slavery shall exist no longer." And he proposed as an amendment "that from the first day of the next year every slave born within the King's Dominions should be free." The amendment was greeted with loud and long applause, and carried with acclamation.

In the same year a great meeting was held in Edinburgh at which Dr. Andrew Thomson said: "We ought to tell the legislature plainly and strongly that no man has a right to property in man; that there are 800,000 individuals sighing in bondage under the intolerable evils of West Indian slavery, who have as good a right to be free as we ourselves have; that they ought to be free, and that they *must* be made free." Tumultuous applause greeted this statement.

Attempts were still made to induce the Colonies themselves to bring about the abolition of slavery, but nothing could move the planters. They maintained that slavery was necessary and was not at all an evil.

A Long Fight

But the advocates of abolition continued their uphill work. At last, in 1833, the ministry of Earl Grey took the question in hand, and the Act for the abolition of slavery passed both Houses of Parliament in August and received the Royal Assent on the 28th of that month. A sum of £20,000,000 was voted as compensation to the planters, and in order that there might be no labour upheaval a system of apprenticeship for seven years was established, during which the slaves were bound to work for their masters for three-fourths of each day, the masters in return being compelled to give them adequate food and clothing. All children under six years of age were to be made free at once. Eventually the slaves were given complete freedom in August, 1838, instead of in 1840, as originally arranged.

It was a triumphant ending to a great battle, or rather a war, that had lasted for more than half a century, and the example of Great Britain was gradually followed by the other European States. Some American States also abolished slavery, but the evil lasted on in a large part of the United States, as already mentioned, till the end of 1862.

It is sad to know, however, that slavery still exists in several parts of the world, but saddest of all to think that this is the case in Liberia, a state on the West Coast of Africa which was established as a home for emancipated slaves from America.

A TOWER & A PIT FOR STUDYING THE SUN

In recent years many wonderful telescopes have been built, especially in America, but none is so remarkable in its form as this great solar telescope at Mount Wilson Observatory in California, which has a derrick-like tower rising 150 feet into the air, and is continued by a pit sunk 75 feet into the ground

A very important part of the modern astronomer's work is the study of the Sun by means of that wonderful instrument the spectroscope, which has already been described on page 451.

Now most of the modern apparatus with which the examination of the Sun is made is very large and heavy and cannot be moved easily to follow the movements of the Sun. When therefore the spectroscope with which the astronomer is working is large it is kept fixed and the light of the Sun is reflected to the lens or mirror by means of an instrument known as a coelostat.

The name "coelostat" is made up from two Latin words meaning "the sky" and "to stand," and a coelostat is therefore an instrument which makes the heavens stand still, that is, so far as the spectroscope is concerned.

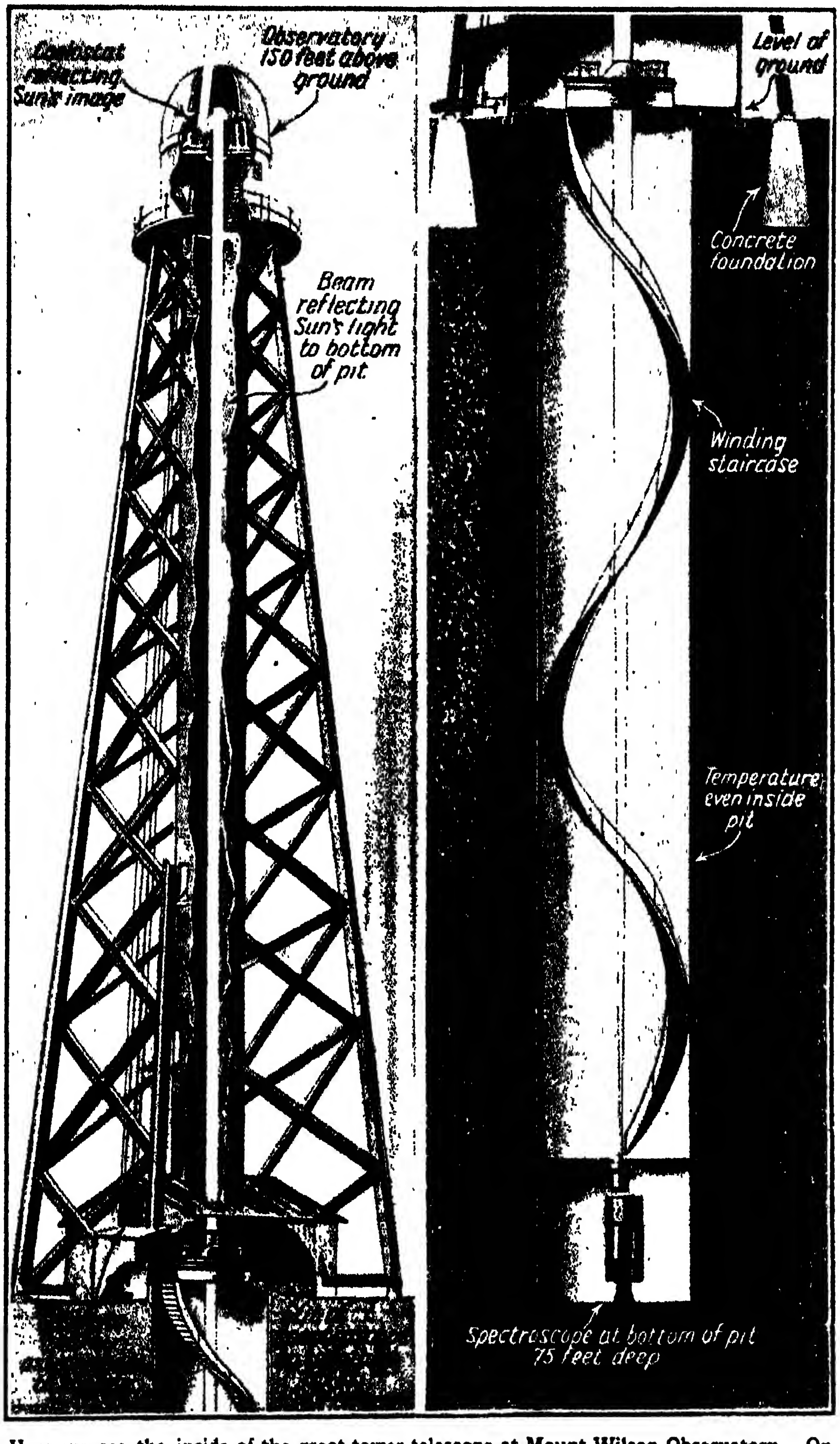
It consists of a plane mirror, mounted on an axis parallel to the Earth's axis, which is rotated by clockwork. From this a beam from the Sun is reflected by a second mirror to the spectroscope and can be kept stationary as the Sun makes its apparent journey across the heavens.

The most remarkable telescope in the world used for studying the Sun is the great tower telescope at Mount Wilson Solar Observatory in California. A photograph of this is given on the next page.

The tower is 150 feet high, but this is not the whole of the apparatus, for it is continued down into the Earth with a pit 75 feet deep at the bottom of which is the spectroscope. In the little observatory perched on top of the tall tower is a coelostat, and this reflects a beam of sunlight vertically downwards through a lens upon the slit of the spectroscope in the pit, where the photograph of the spectrum is taken.

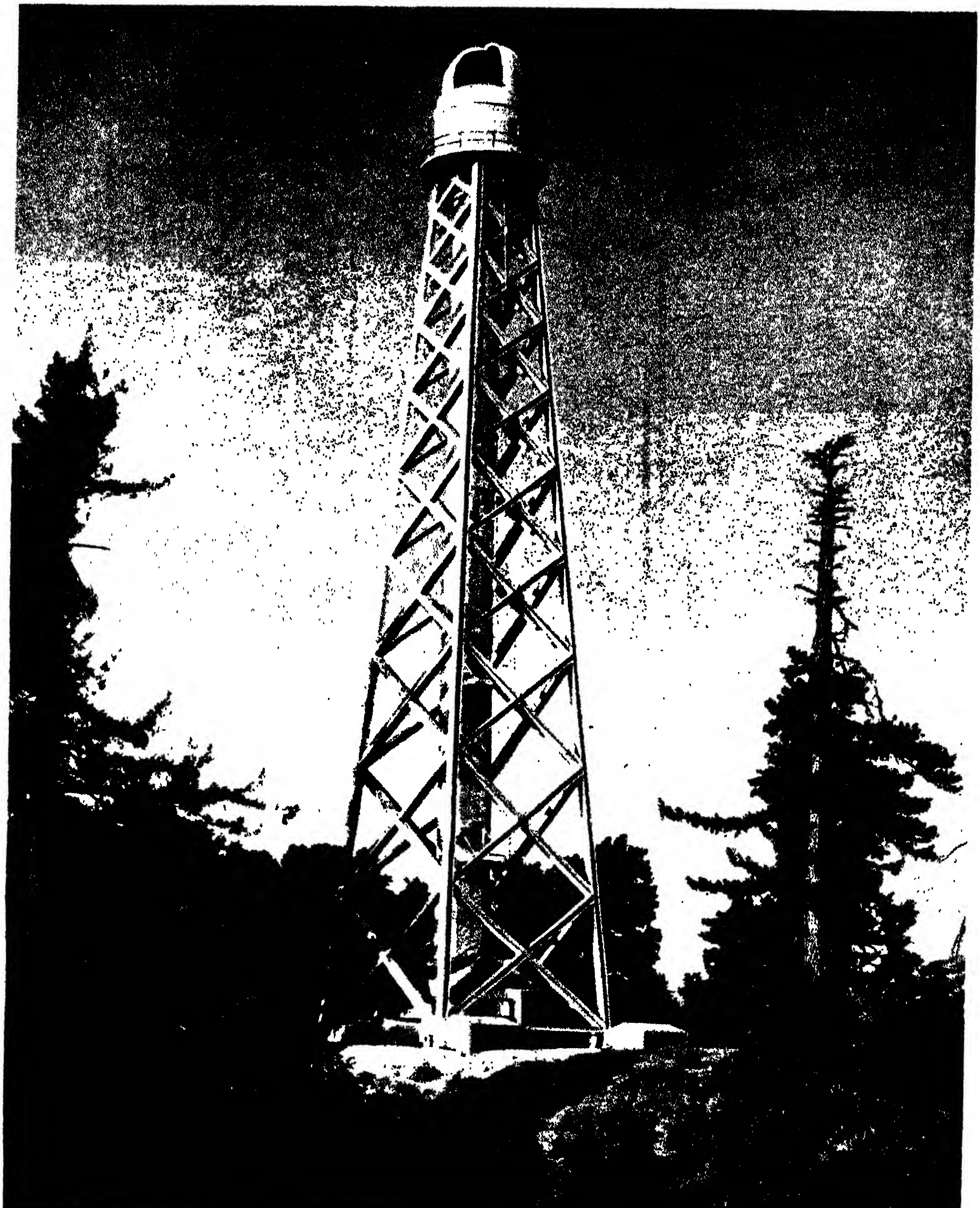
It is necessary when making these careful observations of the sunlight by means of the spectroscope that an even temperature should be maintained. Otherwise the air moves in tremors which cause what is known as "boiling" of the image.

By placing the spectroscope far below the ground level the temperature is kept constant, and by having a tall tower like that of the Mount Wilson telescope, the air at the place where the image is received by the mirror, being so far from the ground, is kept nearly free from tremors.



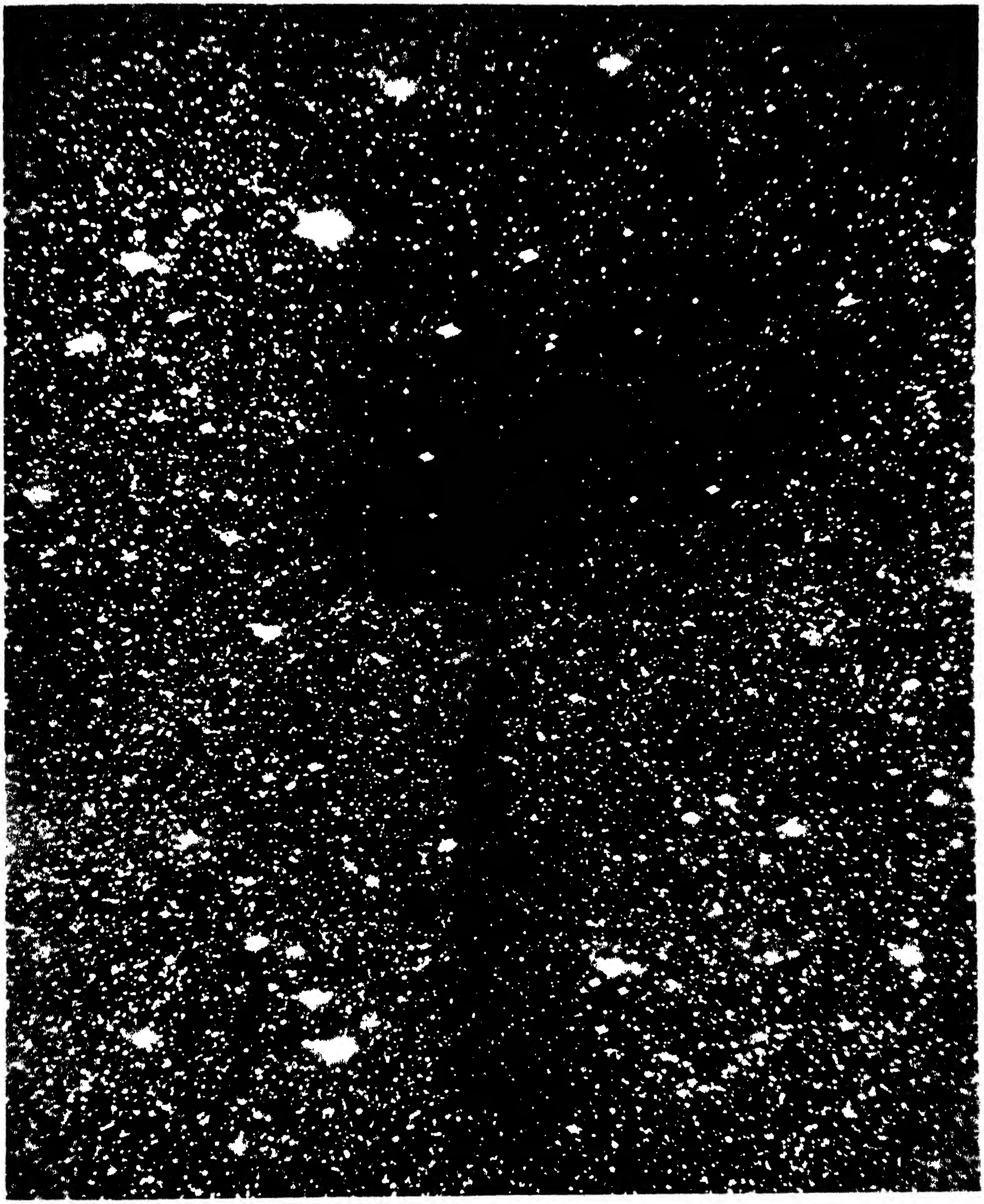
Here we see the inside of the great tower telescope at Mount Wilson Observatory. On the left is the tower with the coelostat at the top to catch the Sun's image, and on the right drawn to a rather larger scale is the pit at the bottom of which the spectroscope is kept. The Sun's beam is reflected from the coelostat to the spectroscope in the pit

THE TOWER TELESCOPE AT MOUNT WILSON



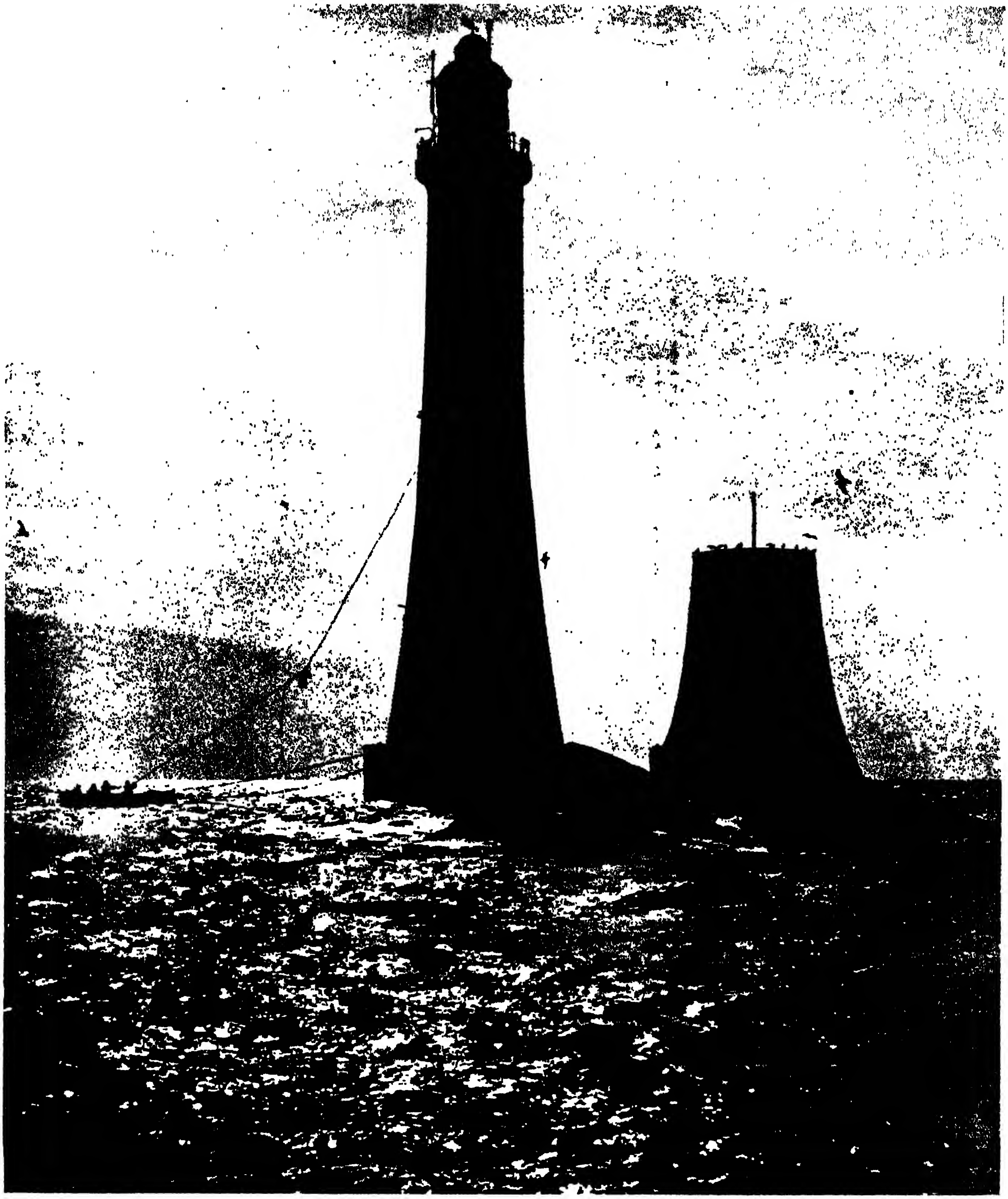
This remarkable telescope is at Mount Wilson Observatory, California, and is known as the tower telescope. It is 150 feet high, but extends down also 75 feet into the ground, and is used for observing the Sun. Theoretically, a telescope has only two lenses, a large lens at the sky end on which the light falls and is focused so as to form an image near the small end of the tube, and another lens at that end which magnifies the image to reveal more detail. Actually both lenses consist of several lenses placed close together

DARK CLOUDS THAT BLOT OUT DISTANT STARS



Here is a photograph taken with the biggest telescope in the world at Mount Wilson Observatory, California, showing part of what is known as the North American Nebula. It is in the constellation of Cygnus, or the Swan, and the photograph shows the northern part of this nebula, where there are black masses that are believed to be enormous clouds of dark gas that blot out the view of the stars beyond them. It was once thought that these black spots were empty spaces in the heavens, but they are much darker than the intervals between the stars. In those intervals there is a faint luminosity due to the light of other stars far beyond, too distant to be seen as individual points of light. These black patches of the nebula, however, are much blacker and astronomers tell us they are undoubtedly dark masses hiding the stars that must lie in vast numbers behind them

EDDYSTONE LIGHTHOUSE AS SEEN FROM A SHIP



The Eddystone Lighthouse is the most famous of all the lighthouses round the British coasts, and it was the first of the modern type built in the form of a tree trunk, with its blocks of masonry interlocked with one another and with the rock on which it is built. Here we have a remarkable photograph taken against the setting Sun, showing the lighthouse in silhouette, as seen from the deck of a ship some little distance away Close by is the stump of Smeaton's lighthouse, erected in 1759, which was used as a beacon till 1882, when the newer lighthouse was completed and brought into service. The beam of the present lighthouse shines out 135 feet above high-water mark, but from the bottom of the lowest course of masonry to the top of the lantern the height is rather more than 170 feet. From this point of view we get, of course, the best idea of the lighthouse. If the photograph were taken from a boat near the base we should get a wrong impression of the general contour of the building, and if it were taken by an airman from above it would look a mere speck. On the left we see the relief boat and provisions are being hauled up from it to the lighthouse

WHY THINGS LOOK SMALL AT A DISTANCE

While everyone knows that an object viewed from a distance appears smaller than when seen close at hand, the reason for this fact is not so well known. The pictures on this page and the previous one explain the matter

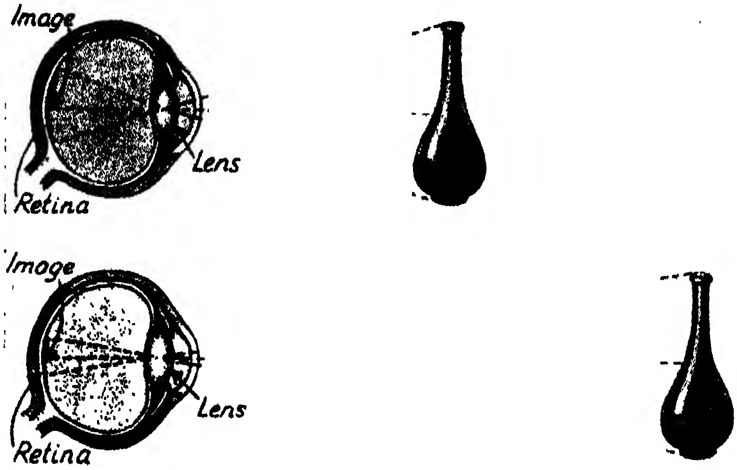
We must all have noticed that the farther away a thing is the smaller it looks. A railway train seen from a mile away looks like a boy's toy train. The Isle of Wight seen by an airman three or four miles up looks like a paving stone, and if we look down an avenue of tall trees the trees appear smaller and smaller the farther they are from our eye.

Why is this? Well, when we look at an object, say a tree or a vase, rays of light come from the top of it and from the bottom as well as the other parts, and passing through the crystalline lens in front of our eye cross and are focused on the yellow spot on the retina or curtain at the back, which is the real seeing point of the eye.

The size which the object appears to have depends upon the angle with which these rays meet when they cross one another in the crystalline lens. The wider the angle the larger the object appears, and, on the other hand, the smaller the angle the smaller the image of the object.

As we can see from the diagrams on this page, the angle gets smaller the farther away the object is from our eye, and the smaller the angle, it is clear from the diagrams, the smaller must be the object thrown on the retina.

The horizontal line in the diagrams is called the principal optic axis, and the angle at which the slanting rays cross in the lens is the visual angle. If we look at an object with both eyes rays of light pass between the object and the eyes, and the angle which these rays make where they meet on the object is the optic angle



When we look at an object rays of light from the top and bottom as well as from other parts meet in the lens of our eye and cross one another, forming an image on the retina or curtain at the back. The size of the image on the retina depends upon the angle at which the rays from the object cross one another in the lens. This is made clear by these diagrams. The upper one shows the object near, the lower one shows it farther away

The effect of distance on an object is clearly seen in this photograph taken at Beachy Head. The lighthouse built in the sea is a tall tower, but seen at a distance from the top of the cliff, as shown, it appears only like a tiny model of a lighthouse. Contrast the lighthouse as seen from this point of view with the photograph of the Eddystone Lighthouse on the opposite page, seen much nearer from the deck of a ship

SIMPLE EXPERIMENTS WITH A MAGNET

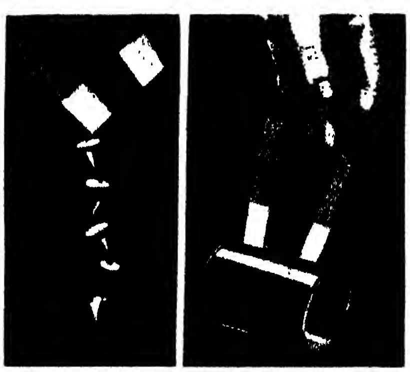
Most boys and girls possess a horseshoe magnet and amuse themselves by lifting tacks and other iron objects but we may carry out a number of interesting experiments with the magnet which will teach us a good deal about the mysterious power of magnetism.

The horseshoe magnet is simply a bar magnet bent round into the rough shape of a horseshoe so as to bring the two ends near to one another and thus act together upon the same piece of iron. One end of the magnet is called the north pole and the other the


The magnet attracts iron filings to its poles

south pole. It would be more correct to call these the north-seeking and south-seeking poles, as we shall see.

Let us suspend our magnet by a bootlace from a bar. The magnet will swing round to and fro for a moment or two till it comes to rest in a certain direction. If now we give the magnet a twist it will swing round again, but will eventually come to rest hanging in the same direction as before. This direction is north and south. The reason is that the Earth is a magnet and the poles of the hanging magnet


The big magnet turns a chain of tacks into magnets. On the right a canister made of tinned iron is held up

seek the North and South magnetic Poles of the Earth.

Now let us dip our magnet into a box of tacks or iron filings. When we take it out there will be a cluster of tacks or filings adhering to each pole of the magnet. Not only will those tacks that are in actual contact with the magnet adhere, but others which are not touching the magnet but are in contact with other tacks will be held.

The tacks adhering to the magnet themselves become magnets by what is


A suspended magnet turns north and south

known as induction. We can prove this by another experiment. Suspend one tack to one of the poles of the magnet. Now to the end of the tack suspend another and then another. We shall thus get a chain of small magnets by induction.

Next let us spread some tacks or iron filings on a post card and move the poles of the horseshoe magnet about underneath the card. The tacks will be moved by the magnet, for the magnetism acts through the card. The same thing happens if we put the tacks on the table and move the magnet under the table, in contact with the wood.

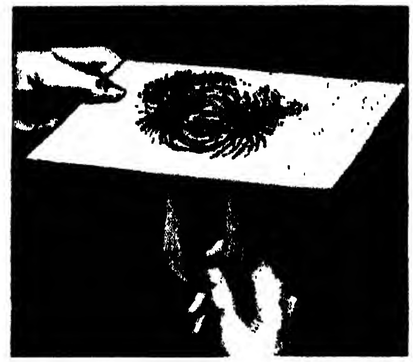
If we hold the magnet to a small tin it will attract and support the tin. Why is this, for a magnet will not attract tin? The reason is that a tin is really made from sheet iron coated with tin.

Place a compass on the table and


A floating magnetised needle comes to rest pointing north and south

bring the magnet near. The compass needle will move. We shall find that the north pole of the magnet will repel the north pole of the needle for like repels like, but the magnet's south pole will attract the needle's north pole.

Now let us make a new magnet. We take a large darning needle and stroke it several times along one arm of the magnet, always in the same direction. After a few strokes it will have become a magnet and will attract iron filings. Make another similar needle a magnet. Now suspend one by a thread. It will hang north and


The magnet's power exerted through card

south. If we bring the other near it, we shall find that like poles repel and unlike attract.

Next lay one of the magnetised needles on a small piece of card or paper on a bowl of water. The needle will turn the card round till the needle is floating facing north and south. The same thing happens if the needle is stuck through a small cork and set floating.

If instead of a horseshoe magnet we get a bar magnet we can make another magnet by stroking a bar of steel with


A needle magnetised by stroking it again and again in one direction across one pole of a magnet

one pole always in the same direction. It does not matter which pole of the magnet we use.

Many other interesting experiments with a magnet will suggest themselves to any clever boy or girl who gives the matter careful thought.

WONDERFUL FORCE OF NATURAL INSTINCT

As told in page 1307, the salmon divides its life between fresh water and salt. In the sea it feeds and grows strong until, in late autumn or early winter in Great Britain, it is impelled by instinct to ascend a river to spawn. Its eggs will develop only if deposited near the source of a stream, in shallow fresh water flowing quickly over a gravelly bed. To such a place the adult salmon makes its way, whatever the obstacles in its path ; it will even (like the specimen above) leap and leap again until it has surmounted a waterfall

To face page 1321

RIVERS THAT FLOW OVER A PRECIPICE

There is no physical feature on the Earth's surface that is more majestic and inspiring than a great waterfall. Such falls as Niagara and the Victoria Falls in Africa inspire all beholders, and man never feels smaller than when in the presence of one of these rushing cascades. Here we read how the waterfalls have been formed

A WATERFALL is really a river flowing over a precipice. This is seen clearly in the case of Niagara, where the Niagara River suddenly makes a descent of 155 feet and then continues its course to Lake Ontario.

A few big waterfalls stand out in the popular imagination, as, for example, Niagara and the Victoria Falls on the Zambezi River in Africa. But there are thousands of waterfalls, many on a big scale, in different parts of the world.

Such falls occur generally in mountainous country, and they are often due to a change in the geological structure of the rocks. A mass of hard rock, through what is known as a fault, or some other cause, is in contact with a much softer formation, and the river in the course of ages wears away the softer rock till at last it pours over a precipice of harder rock that is left. In the course of time it wears this also away, but very slowly.

Niagara, as we know, retires a little farther every year by the wearing and falling of the rocky cliff over which it pours. Even where a river flows over a hard layer of rock there is often softer rock in the strata below, and as this is worn away by the action of the water the overhanging hard rock becomes top-heavy and at last falls. We see how this occurs at Niagara in the pictures that are given on page 47.

A common cause of a waterfall is the accidental diversion of a stream from its original course. This has happened in a good many cases in the United States, a diversion being due to the interference by a dam built up of glacial deposits in a far-distant age. Boulders and drift material carried down by the glacier have accumulated and turned the river in the direction of a precipice over which it now descends. Sometimes the fall is broken up, and then, instead of a majestic descent of a hundred feet or more, there is a series of cataracts.

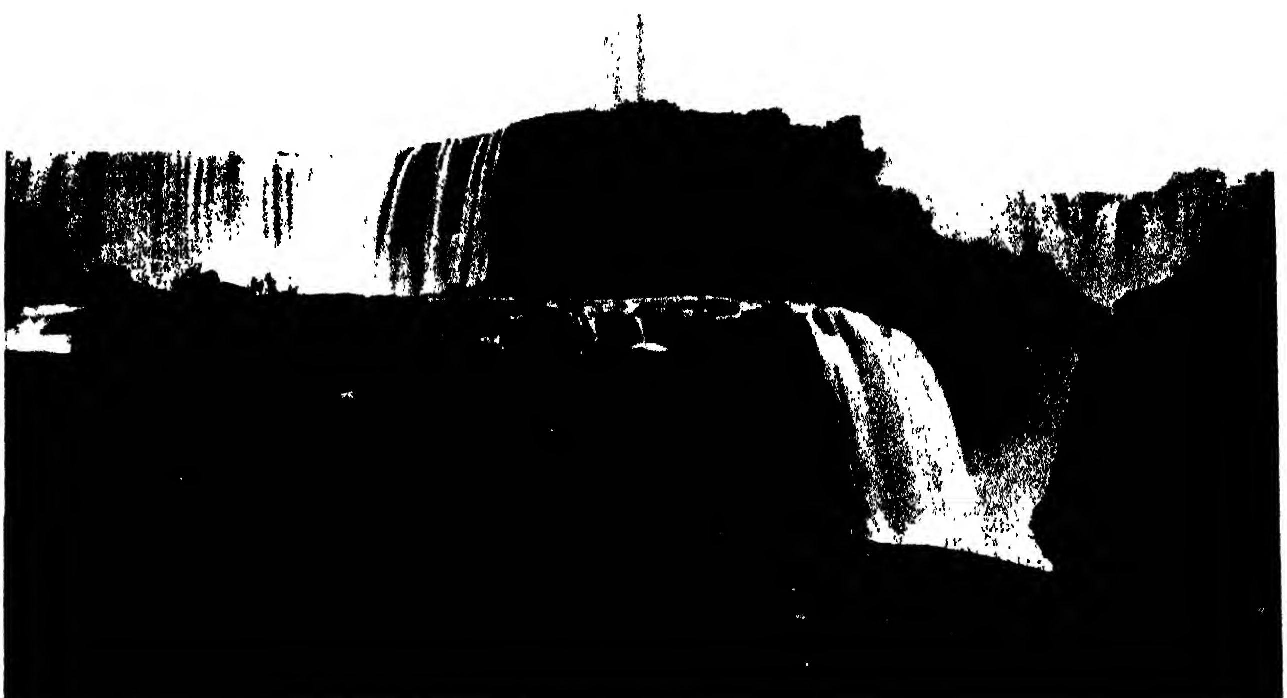
In the United States alone there are thousands of waterfalls, many of them of considerable dimensions.

While the majority of waterfalls are found in mountainous districts, there are some in more or less level country, though they are by no means so common, and their depth of fall is much less. But what is lost in depth is made up in greater volume of water. Such falls generally occur where a river passes from a higher to a lower plateau or plain, the upper plateau being edged with hard rock.

Waterfalls used to be regarded merely as beautiful natural phenomena, but now they are looked upon as sources of power, and more and more of these falls are being harnessed for use.

As to the depths that the water descends when it topples over the precipice, this varies enormously in different parts of the world. Victoria Falls are 357 feet, but there are scores of waterfalls in the world that have much greater drops. The Widow's Tears in the Yosemite Valley for example, fall 1,170 feet, and in the same valley there are two other falls even greater. The Upper Yosemite Falls are 1,430 feet, and the Ribbon Fall 1,612 feet. The Roraima Falls in British Guiana are 1,500 feet deep, and the Sutherland Falls in New Zealand 1,904 feet, while there are falls on the Tugela in Natal of 2,000 feet.

Where a country has no coal or oil supplies, but an abundance of falling water, it is able to produce a cheap and adequate supply of electric power for transport and industrial purposes.



The awe-inspiring falls on the Laga River in Central Chile, south of Valparaiso. These falls, which are aptly called the Niagara of South America, are a worthy rival of the actual Niagara Falls in North America. A vast volume of water pours over this rocky precipice every hour, and plans are being drawn up to utilise the water power for the production of electricity

THE MOST TREMENDOUS EXPLOSION IN HISTORY

There were some tremendous explosions of ammunition dumps during the First and Second World Wars, and there have been even more terrific explosions as the result of detonating atom bombs.

But never in recorded history has there been an explosion like that of Krakatoa in the Strait of Sunda between Java and Sumatra, when this volcanic island blew up with a titanic roar that was heard in Southern Australia 2,200 miles away and on the island of Rodriguez 3,000 miles distant.

This amazing explosion occurred on August 27, 1883, and two-thirds of the island were blown away. Where the mountain stood in the centre of the island there was afterwards a depth of sea of more than a thousand feet.

When we throw a stone into a pond a series of ever-widening ripples is created on the surface of the water and eventually reach the margins of the pond. The Krakatoa explosion set up vast waves in the sea which travelled half round the Earth and on their way rose fifty feet at the neighbouring islands. The coasts of Java and Sumatra were inundated, nearly 300 villages were swept away and over 30,000 people drowned.

The waves set up in the air by the huge explosion were even more wonderful. A series of gigantic waves was propagated through the air, which embraced the whole globe, and travelling in both directions from Krakatoa met on the other side of the globe and then diverged to meet again at the scene of the explosion.

A second time the waves spread round the Earth and a second time returned. Seven times, says Sir Robert Ball, did that marvellous series of waves encircle the globe and affect the reading of every barometer in the world. The waves took 36 hours to travel from Krakatoa to the island's antipodes and the same time to return.

It was estimated that the dust and steam were shot up into the air for over twenty miles, and the sky over a large area became black as night. The intense darkness spread for a distance of 180 miles all round.

As to the noise, at Batavia 94 miles away it was deafening. At Macassar in the Celebes 969 miles distant it was so loud and seemed so near that ships were sent out to see if a near-by vessel was in trouble. In the island of Timor 1,351 miles away the people were scared by the sound. The noise of the explosion took more than four hours to travel across the Indian Ocean to the island of Rodriguez 3,000 miles away.

Three times the dust from the volcano travelled round the Earth, giving rise to very beautiful sunsets which were seen in London. Even the Moon's appearance, as seen in Europe, was changed by the dust in the atmosphere.

There has never been such an explosion in history.

The island of Krakatoa as it must have been in past ages

The island after a great mass was blown away in geologic times

The crater ring at a later date filled with small cones

The form of Krakatoa just before the great upheaval of 1883

Krakatoa to-day with deep sea where formerly there were craters

The island of Krakatoa and its surroundings, as seen from the air before the great explosion of 1883 and, on the right, after the explosion. A great part of the island way blown away in a few moments, and where formerly there stood a mountain there was, after the great upheaval, no land but only a deep sea

STRIKING EXAMPLES OF THE WEARING OF THE ROCKS

This photograph, taken in the Yoho Park, British Columbia, shows a remarkable collection of earth pillars in which massive boulders are supported on columns of softer rock, as though perched there by some giant hand. The method of their formation is shown in the explanatory pictures on page 1139. They have stood like this for many thousands of years

Here is a very remarkable example of rock erosion. The photograph was taken in the Bryce Canyon of Utah, where the rocks are beautifully coloured in blue, yellow, red, brown and grey. The carving of the pinnacles, giving the impression of an Eastern temple, was performed by wind-driven sand. Another picture of the strange rocks of Bryce Canyon appears on page 754

HOW THE SEA VARIES IN TEMPERATURE

ANYONE who bathes knows how very much the sea varies in temperature. Even in the course of a day or two it may change a great deal, and in different parts of the world the variations are far greater. In the Arctic and Antarctic the water is almost at freezing point, while in the upper part of the Red Sea it is about 90 degrees.

Speaking generally, it is the strength of the Sun's rays that makes the water warm or cold. These rays do not penetrate into the sea to a greater depth than about 600 feet, and the consequence is that the deep water, which is the greater part of the entire ocean, has a much more regular temperature at any given spot throughout the year than the surface water.

At the surface the water changes according to the season, and it is also greatly affected by currents. Naturally the surface of the ocean, like that of the land, is warmer near the Equator to the Poles. Many rivers enter the sea and these often in summer bring water that is warmer than the sea-water, while in winter their water is sometimes colder than the sea.

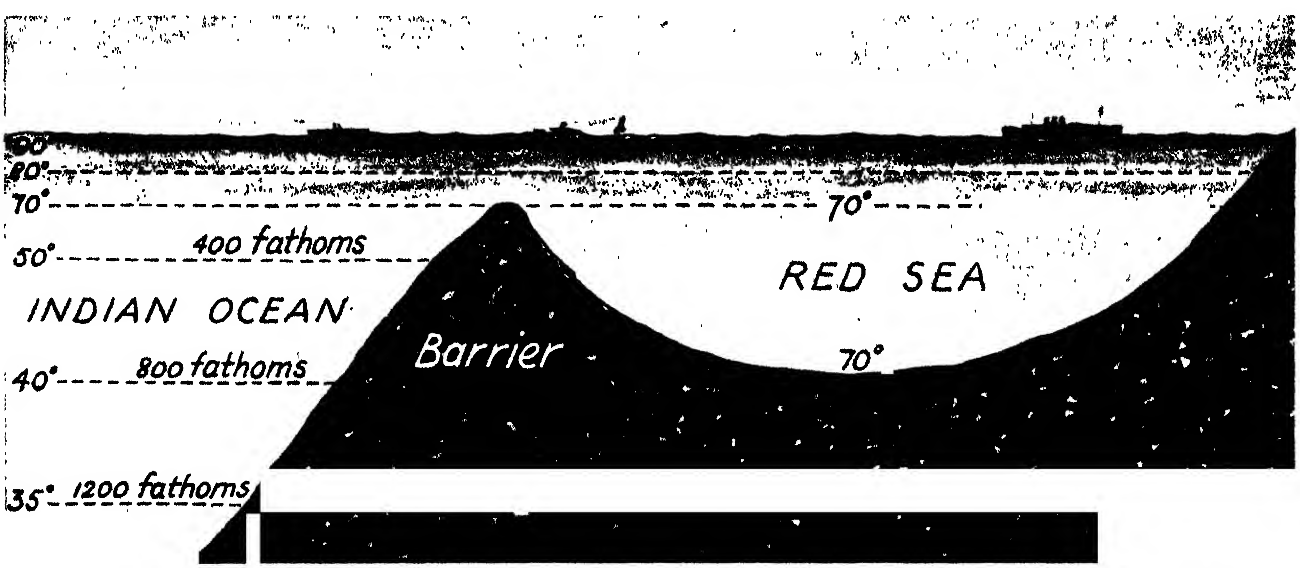
The surface of the sea is always cooler at night than during the day, and it is cooler in winter than in summer. These changes from day to day and from season to season are much less than those of the land in the same latitude.

When, however, we come to go deeper than the surface we find that the water becomes cooler with increasing depth. There is an exception, however, where the surface water is nearly freezing.

Even where the surface water is warmest, as in the equatorial regions, the temperature, directly we go a few hundred fathoms down, gets very low. On an average when we go 600 feet below the surface the temperature is just over 60 degrees Fahrenheit; at twice that depth, namely 1,200 feet, it sea, where the temperature falls from about 75 degrees at the surface to 55 degrees at a depth of 750 feet, and then remains unchanged to the bottom, which is 13,000 feet below the surface. At this depth the temperature of the ocean outside is 37 degrees Fahrenheit.

What is the reason that these enclosed seas show such a high temperature deep down? Well, the reason is that there are sunken barriers of rock which shut them off more or less from the open ocean. The result is that the colder and denser water outside is prevented from flowing in and displacing the warmer and lighter waters that lie below the top of the barrier. The picture-diagram on this page illustrates this point.

As a matter of fact, the temperature of the bottom of these enclosed seas is often about the same as the temperature of the sea-water at the level of the top of the barrier, which separates them from the ocean.



In this picture-diagram we see a section through the Red Sea and the part of the Indian Ocean which joins it The temperature of the surface water is the same in both seas, but as can be seen, a great rocky barrier shuts off the deeper part of the Indian Ocean from the Red Sea, and prevents the colder water of the Ocean's lower depths from flowing in. The result is that the temperature of the Red Sea below the surface remains the same as it is at the top of the barrier, namely, 70 degrees Fahrenheit

and gets cooler towards the Poles. Near the Equator the temperature of the surface water is generally about 80 degrees Fahrenheit, while near the Poles it is about 28 degrees Fahrenheit. That, of course, is below the freezing point of fresh water, which is 32 degrees Fahrenheit, but it takes greater cold to freeze salt water than fresh water.

The temperature of the surface water depends a great deal upon the currents. Some of these are cold and flow into warmer water, lowering the temperature. The Labrador current is a good example of this On the other hand, a warm current often flows into cooler water raising the temperature, and the Gulf Stream is a striking example of this.

But there are other reasons why the surface water of the ocean does not get colder steadily as we travel from the is 50 degrees; at 3,000 feet it is about 40 degrees; at 6,000 it is 36½ degrees.

Men of science who have studied the sea tell us that not more than one-fifth of the water of the ocean has a temperature as high as 40 degrees Fahrenheit. The average temperature of the whole of the sea is reckoned to be about 39 degrees Fahrenheit. At the bottom of the deeper parts the temperature is below 35 degrees.

These facts, however, do not apply to the deeper parts of enclosed seas. For instance, the Red Sea, which is about 3,600 feet deep, often has a temperature of 90 degrees Fahrenheit at the surface. This is reduced to 70 degrees at a depth of 1,200 feet, and it remains about the same to the very bottom.

A similar state of things is found in the Mediterranean, another enclosed

The great mass of deep sea-water is cold because cold water at the surface always tends to sink owing to its greater density, and as the supply of icy water from the polar regions is very great, there is a constant supply of cold water to go on sinking. When the ice caps melt the cold water is fresh, and therefore lighter than sea-water, but it soon gets mixed with the salt water and then becomes heavy enough to sink.

It might be asked how men discover the temperature of the water deep down in the ocean. Well, they have two methods. One is to let down specially constructed thermometers which register the temperature, while another is to lower special bottles which bring up specimens of the deep water.

THE GREAT WONDER OF THE HUMAN HAND

For most of the things we do we use our hand. We pick up things with it, we write and draw with it, and we make things with it. Yet how little thought we give to it till some injury prevents us from using it! The human hand is one of the greatest wonders of our body, and, as we read here, it is marvellously adapted to do the great variety of work required of it

The human hand is one of the most wonderful tools in the world. Many creatures have something corresponding with the hand, like the crab or lobster with its claw, the birds with their claws, the reptiles and mammals with their forefeet, and, nearest of all to man, the monkeys

In the case of many of the monkey folk there are the four fingers and a thumb, and the thumb can be turned round to oppose the other fingers so as to close on an object.

But it is only in man that the hand becomes the perfect tool. It is not used, as in the case of the apes, chiefly for laying hold of branches in climbing and for conveying food to the mouth, but far more for the grasping of loose objects of all kinds.

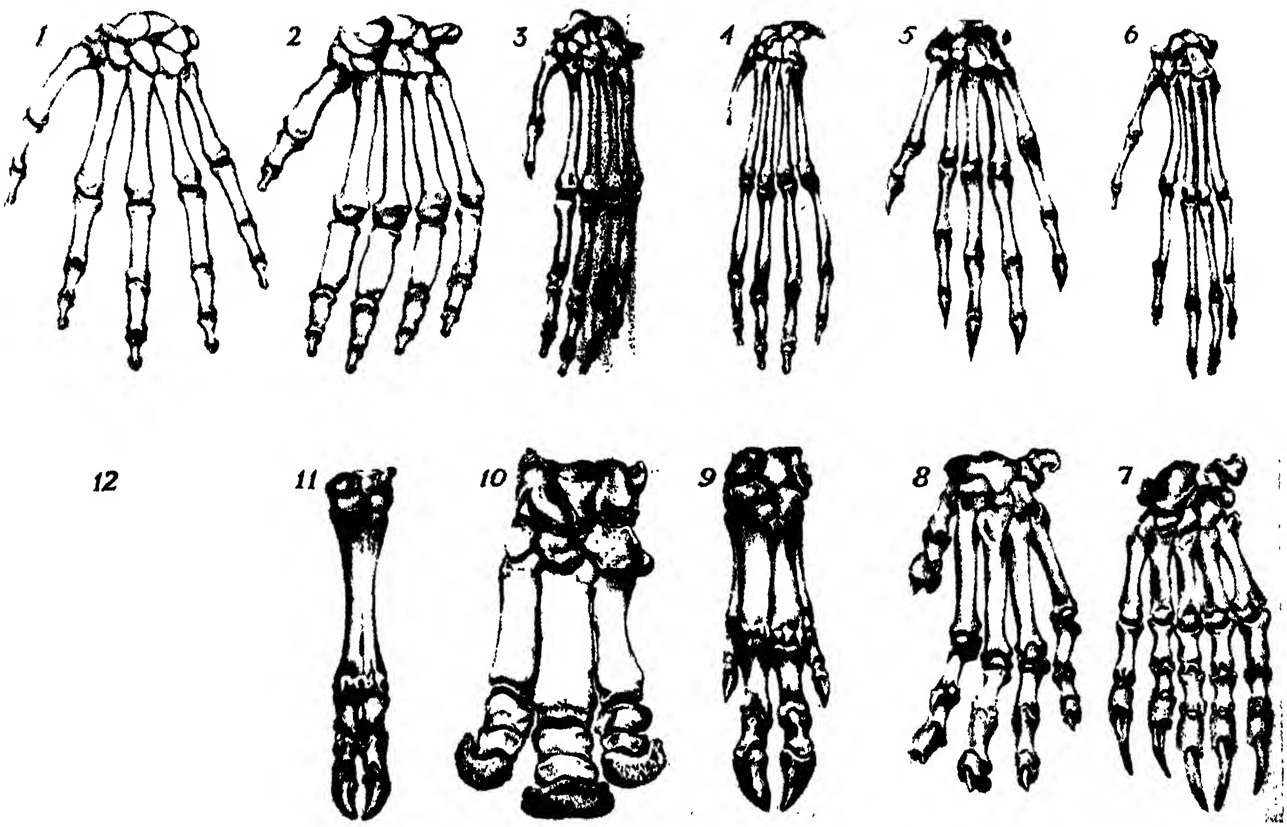
By linking his brain with his hand, it has been said that man is able to make for himself an unlimited number of what are really additional organs, derived not from his own body but from the things about him.

Using the hand as a tool, man is able to fashion all kinds of other useful tools which do certain kinds of work more efficiently than the hand itself, till at last the hand has produced the marvellous machinery of which we see so many examples in this book.

We never realise how much we use our thumbs, but when a man loses his thumb, then he understands its supreme importance. Let us try to grasp a stick without using our thumb, or to pick up a cup of tea, or to use a hammer, or to sharpen our pencil, or to write, or even to shake hands with a friend. In every operation that we carry out our thumb plays a very important part.

In the man-like apes, which are nearest to ourselves in the shape of the hand, the thumb is very much smaller in proportion to the fingers, and very much less efficient than in man. Most monkeys walk on all fours, using their hands as feet and placing them flat on the ground But they can grasp things also in true hand fashion.

The chimpanzees and other man-like apes use their hands in walking on all fours, but instead of resting the palm of the hand on the ground they fold up the hand and place the back of all the fingers or the knuckles on the ground. Man uses his hand for far more important purposes



In these pictures we see the bones of a man's hand and also the bones of the corresponding part of a number of other animals. It is interesting to compare these and note the points of similarity and difference. In each case the picture shows the end of the left fore limb of the animal. 1. Man ; 2. Gorilla ; 3. Orang-utan ; 4 Spider Monkey ; 5. Marmoset ; 6. Lemur ; 7. Bear ; 8. Lion ; 9. Pig ; 10. Rhinoceros ; 11. Ox ; 12. Horse. The variation from the human form of hand gets more and more marked as we proceed through the list. In the lower row there is no thumb to be opposed to the fingers for grasping

THE FLOWERS AND FRUITS OF THE CACTUS PLANTS

When we think of the cactus family we usually associate the name with plants of strange forms, possessing thick skins and formidable spikes to warn the animals including man, that they must keep away and not try to steal the water stored up inside the plant's fleshy stems.

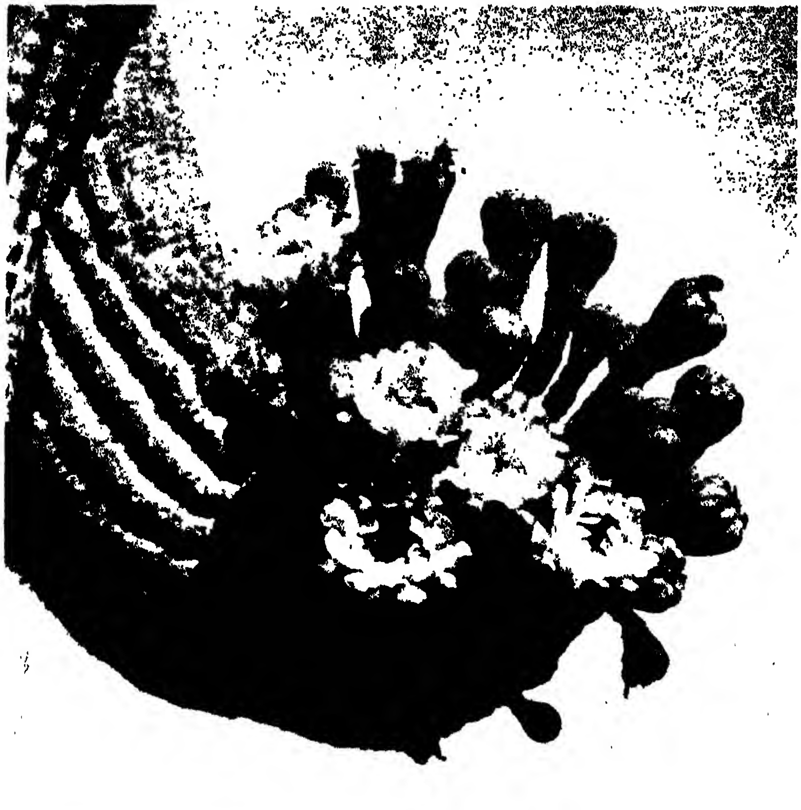
But the various forms of cactus are something more than freaks and curios. They bear very beautiful flowers of striking colour and these flowers in many cases develop later into attractive edible fruits.

A cactus certainly looks very strange when it is in blossom, for the flower has the appearance of being taken from some other plant and stuck on the cactus as a joke.

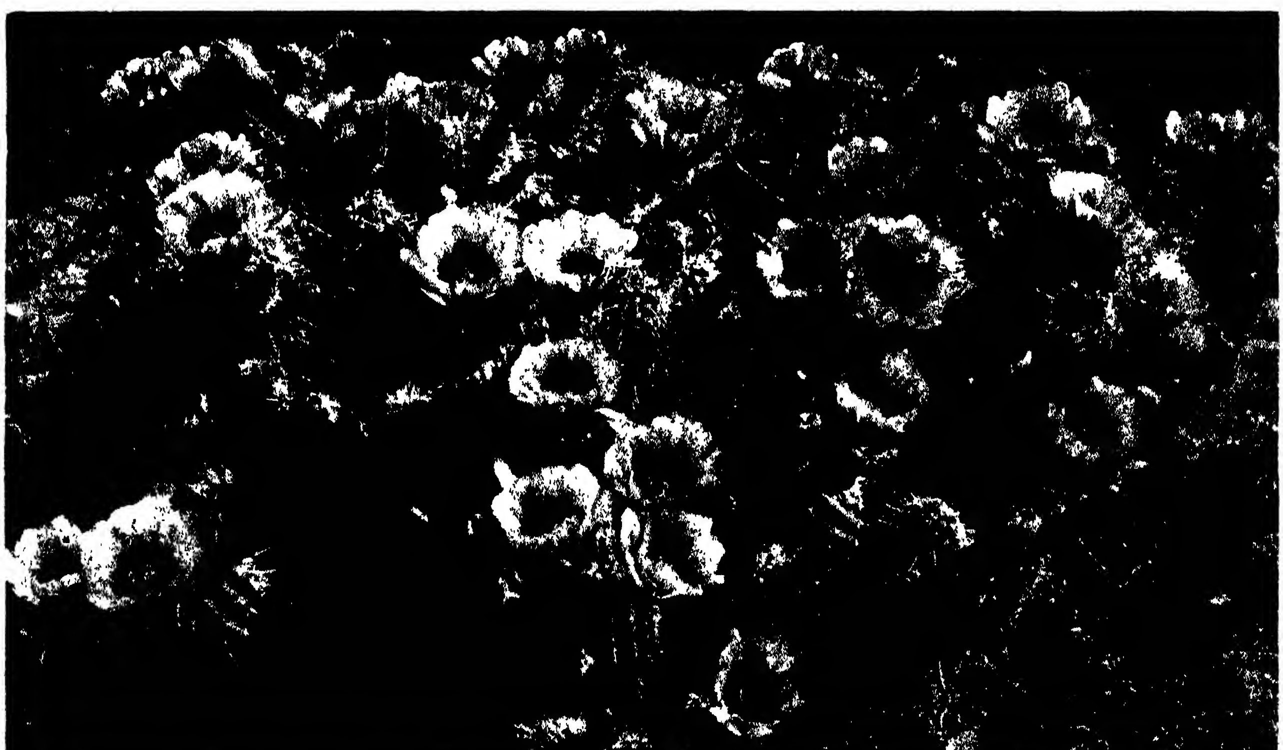
The prickly pear cactus which has become such a pest in Australia has an attractive reddish yellow flower and the egg-shaped or pear-shaped fruits are juicy and sweet, and are much eaten. In the south of Europe and North Africa the prickly pear is cultivated as much for its fruit as for its use as a fence or hedge.

The giant cactus of Mexico, the biggest species of the whole family, which grows in column-like stems to a height of sixty feet or more with a circumference of over six feet, has large flowers which produce green oval fruits that make an excellent jam or can be dried for food. The natives of Mexico make much use of it in its dried form, storing it up for use in times when other food is scarce.

Even the hedgehog cactus often seen in English greenhouses has large and showy flowers growing from the top.



The beautiful white blossom of the saguaro, a giant cactus that grows in the arid parts of North America. It is one of the most strangely placed blossoms in the world



A group of cactus plants in blossom in the desert region of Arizona. The green parts of the cactus contain much water. How effectively the plants protect themselves against animals that would prey on them can be clearly seen by the armoury of bayonet-like spikes

A SYRIAN BEAR WAITING FOR A BUN

There are a number of varieties of the brown bear and one of these is the Syrian bear shown in this picture. It is the bear so often referred to in the Bible, the bear which David slew when he was a shepherd boy. It was formerly very common in Syria and Palestine but is getting rarer and rarer there. As a cub it is dark brown but gets lighter as it grows older, and in old age is almost as light as a polar bear. It can walk about on its hind legs, as we used to see it doing in the streets of London and other cities, when it was led round by an Italian trainer. The bear has five toes armed with powerful claws on both the fore and hind feet, and when walking the whole sole is applied to the ground so that the impression left is very much like a man's footprint. The bear rarely attacks man unless first attacked, but when it does it strikes round with its claws and inflicts terrible wounds. It is this action that has given rise to the otherwise entirely unfounded legend that bears hug their victims

INSECTS THAT BUILD SKYSCRAPERS AND SINK WELLS

The white ants are neither white nor ants. They are generally coloured more or less like the earth they live in, and are far more nearly related to the mayflies and dragon-flies than to the ants. Their proper name is termites.

They live in communities like the bees, and very wonderful they are. There is a queen who lays eggs at the rate of thousands a day for months together. There are workers which some become workers, some soldiers, and a few winged kings and queens.

The winged insects fly about for a time, and then shed their wings. Many are devoured by birds, but when a king and queen insect are seen near a termite burrow, the workers take them inside and place them in a special cell prepared for them, where they become the parents of a new colony.

The food of white ants consists mostly lands in which they live are generally dry. So they burrow down into the ground and sink wells sometimes seventy or eighty feet below the surface. Having tapped a supply of water, they form processions of workers up and down the burrow to bring water to the top. With this water they irrigate beds in which they plant and grow thousands of tiny mushrooms that form part of their food. They also warm

The white ant or termite is a tiny insect but it is exceedingly industrious, and a colony of termites will build great skyscrapers reaching a height sometimes of forty feet. If man erected buildings as tall in proportion to his own height, he would have skyscrapers nearly a mile high. Here is a termite nest on a golf course in the Belgian Congo. Sometimes the nests are pinnacled like a cathedral

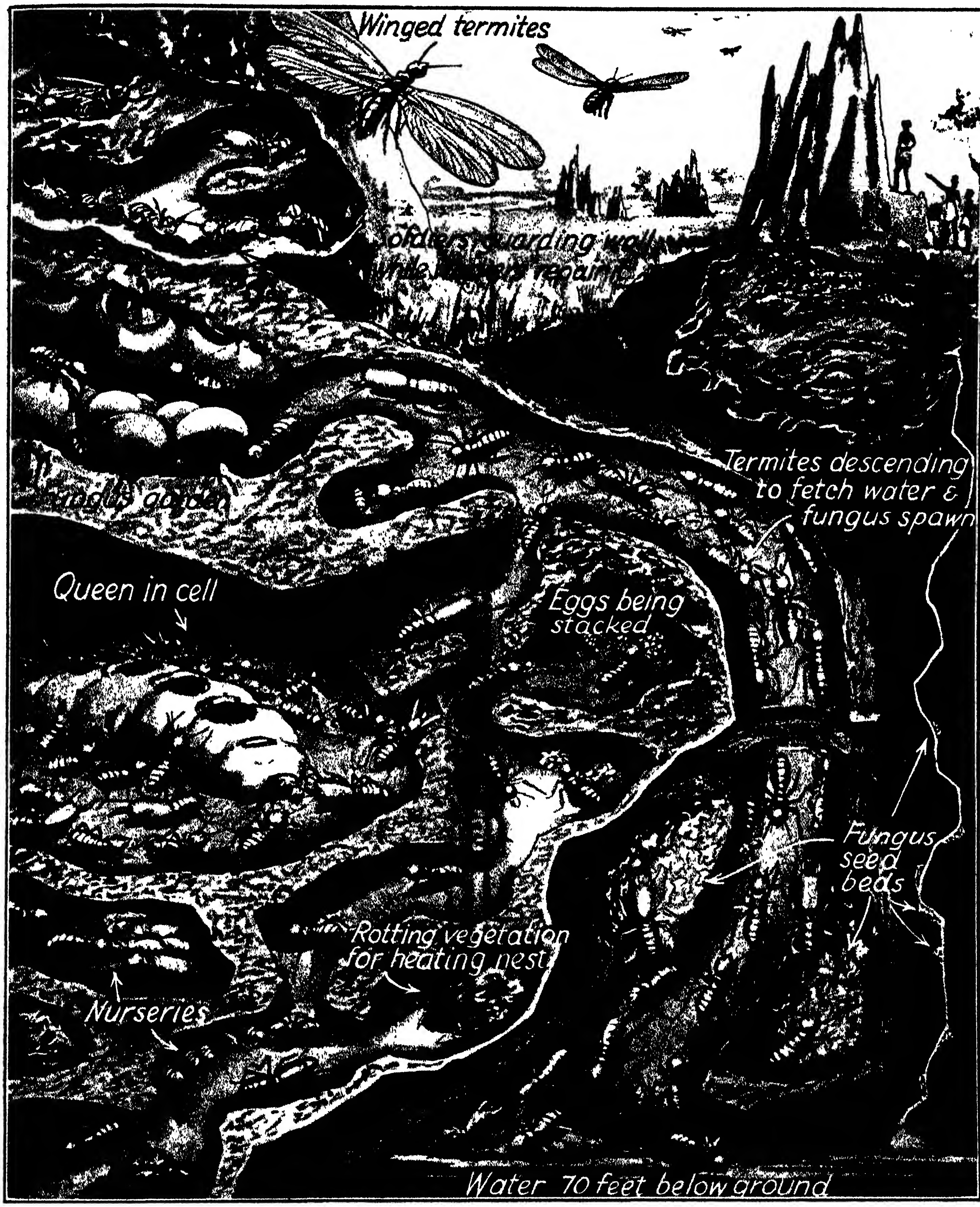
build and tunnel and carry water and look after the young larvæ that hatch from the eggs and attend to gardens in which minute mushrooms are grown. There are soldiers which protect the workers and act in defence of the community as a whole.

When the young larvæ are hatched from the eggs they all look alike, but they are fed by the workers on different kinds of food, and, as a result, of decaying wood and other vegetable matter; they also eat their own dead.

The greatest wonder of the termites, however, is the way they build great mounds of earth thirty or forty feet high, far taller buildings in proportion to their size than the biggest skyscrapers of New York. The earth is changed into a hard material like concrete, and the buildings are very substantial. Then they need moisture, and the their nests by means of decaying vegetable matter, keeping an even temperature, and they ventilate the nests by piercing openings in the walls.

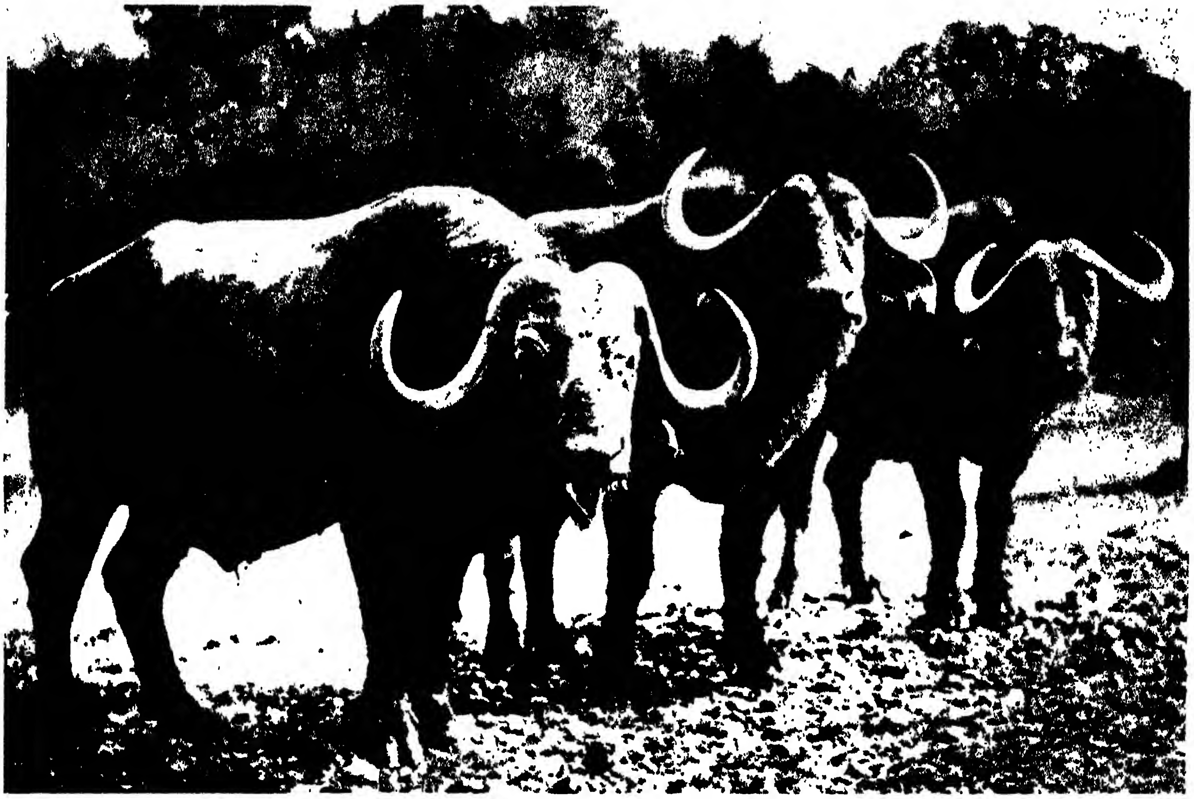
When they once gain admittance to a house, the termites begin preying on everything made of timber till the building and its furniture are ruins. They bore very skilfully inside the wood, eating the whole interior and leaving nothing but a thin outer shell.

THE MARVELLOUS WELL-BORING OF THE WHITE ANT



The white ant, or as it is more correctly named the termite, needs much water to keep the air humid in its nest, but from what source does it get its water in the dry regions where it so often lives and where there is no moisture for scores of feet beneath the ground? Well, the termite sinks a well, a kind of artesian well going down sometimes seventy or eighty feet, to get at an adequate water supply. Then there is a constant procession of insects up and down the well shaft carrying water, which is needed to irrigate little underground gardens where the termites cultivate beds of minute mushrooms for food. They plant the spores and water the growing plants. They have also invented central heating and keep decaying vegetable matter in their nests to give out heat but they ventilate their nests well by making tiny openings in the walls of their houses. Here we see a white ants' nest uncovered, and on the right the deep well

THE AFRICAN BUFFALO WHICH IS A MATCH FOR A LION



The Cape buffalo, of which three specimens are shown here, is the largest and fiercest member of the cattle family. It is not only a massive and powerful animal, but also very swift, and a good horse can hardly keep ahead of a charging buffalo, even in open country. It is supposed to live for about thirty years, and in the nineteenth century, before the numbers were thinned by the sportsman's rifle, the Cape buffalo was often found in herds of from 50 to 300. The Cape buffalo's characteristic feature is the large head with the expanded muzzle and the massive horns, which are flattened at the base and expanded so as to form in old bulls a kind of helmet. When provoked the buffalo is one of the most savage of animals, and in a fight with a lion the buffalo is generally conqueror

BIRDS THAT WEAVE NESTS AND HANG THEM IN TREES

In both the Old World and the New, and also in Australia, there are birds which are remarkably clever weavers, and construct their nests of textile material made by themselves from the fine branches and roots of plants and from flexible grasses which they interlace till they form a kind of cloth

This is sometimes plastered with clay, and the nest is suspended in a tree, where it looks like a bag with the opening at the bottom The shape varies, in some cases the nest looking like a stocking hung up for Christmas The actual nest in which the eggs are laid is in the heel.

The bird begins by making a framework of grass, suspending it from the end of a branch, and then weaves the straws and grasses to form the material from the top downwards.

A group of nests made by the hang-nests, birds of the Amazon forest

It is the male bird which is the actual craftsman, and a tree containing a number of weaver birds' nests is a strange sight. The birds live in colonies, and hundreds of nests may be suspended in one tree.

In the New World the birds that make these nests are generally called hang-nests Their nests are of coarser fibre than those of the weaver birds of the Old World, and in some cases a very miscellaneous mass of material is worked into the nest—fibre, sticks, horsehair, paper, leaves and grass. The weaver birds of the Old World are very much like finches.

Some of these woven nests are used as permanent abodes by the birds, while others have a double chamber, one for the sitting hen and the other as a rest room for her mate.

THE BEGINNING OF THE INDIAN MUTINY

The Indian Mutiny of 1857 should never be forgotten by the British people. It is one of the most dramatic and astonishing episodes in the whole of history and the exploits of valour and endurance that were performed by men and women, warriors and civilians, can hardly be matched anywhere else in the world. Here is the story of its outbreak and how in some parts the mutineers were able to get the upper hand

THE Indian Mutiny in the middle of the nineteenth century showed human cruelty at its worst, but it also showed human bravery at its best. After the revolt had broken out it is doubtful if any other nation but the British could have saved the Empire. We see in the story of the Mutiny what the Oriental can be when he fancies he holds power in his grasp, and we see also what the British fighting man, supported by the gallantry and encouragement of his womenfolk, can do against the most overwhelming odds.

In 1856 British power was supreme in India. There were, of course, native states, as there are to-day, which were allowed to govern themselves under British suzerainty, but in the rest of the country order was maintained by a handful of British troops with a considerable number of sepoys or native Indian soldiers disciplined and trained by European methods, and officered by Britons.

A Dangerous Calm

On the surface everything seemed calm and quiet. The Punjab, which had just been conquered with the aid of sepoy regiments, had settled down loyally under British rule, and the Sikhs of that country appeared more happy and contented than when they were independent.

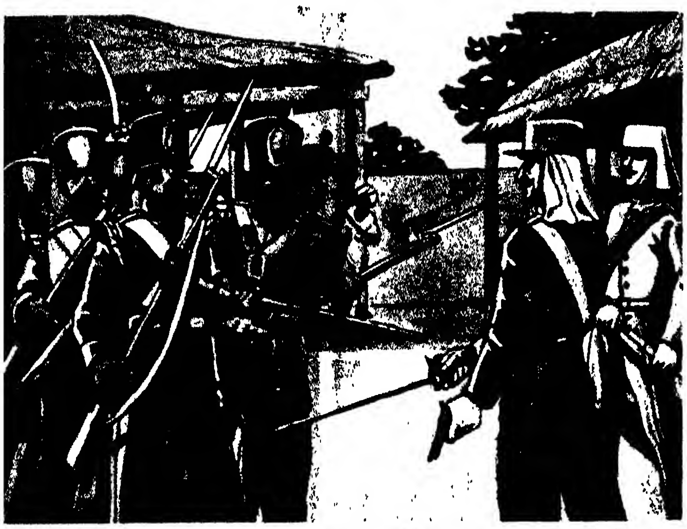
In the Mogul palace at Delhi lived the aged descendant of the old kings with his family. The pomp of a bygone day was maintained by means of a handsome pension paid regularly by the British Government. That any danger was to be anticipated from the infirm old king Bahadur Shah would have seemed ludicrous to the English rulers of India.

But in India, as elsewhere in the Orient, there is generally a good deal going on under the surface. Bahadur Shah had married a young wife in his old age, and when she gave birth to a son it was perhaps natural that she, being an ambitious woman, should want to secure for her son the succession to the nominal title of king, now held by her aged husband.

In July, 1856, the heir-apparent died, almost certainly as the result of poison, and the old king, prompted by his young wife, asked that her child might be recognised as heir by the Governor General. But this request was refused, and Lord Canning pointed out that there was an elder brother of the dead prince who had the prior right.

The young Queen was furious, and in hatred against the British she intrigued in various directions. No one, however, thought for a moment that this Indian princess could work any mischief to the British Government.

It is necessary to bear all this in mind, because it shows that there was a centre of disaffection in India which only needed a spark to cause a great and far-spreading blaze.



The sepoys at Berhampore seized their weapons and shouted defiance

Oriental peoples, ignorant and superstitious, are always ready to believe a rumour or prophecy put forth plausibly, and in the year 1857, which was exactly a century after the battle of Plassey and the establishment of the British power by Clive, there were rumours that circulated from village to village declaring that that year would see the end of the British power.

It cannot be denied that foolishness on the part of the British was to a large extent responsible for the outbreak of the Mutiny. Several silly things were done which should never have been allowed to happen, but having been done the mistakes should have been set right with the least possible delay.

At that time the new Enfield rifle was being introduced into India and with it was used a fresh type of cartridge which in England was greased with beef or pork fat. Now in India to use the fat of cows for any purpose is horrible to the Hindu, and the fat of pigs is almost equally hateful to the devout Moslem. Yet in ignorance, or with a strange indifference to the beliefs of the sepoys, the military authorities in India ordered the cartridges for the Enfield rifles to be prepared at Calcutta in the usual way. There were not wanting secret enemies to point out to the sepoys the facts about the new cartridges.

Seething Disloyalty

The sepoy regiments had become very successful under the tuition of their British officers, and they were beginning to believe that they were as good as British regiments. It was they who really controlled the country, they argued, and why should they do this for the British and not for themselves?

So little of the discontent and disaffection appeared on the surface, however, that right to the end the British officers in most cases really believed in the fidelity and loyalty of their sepoy regiments. Yet under the surface was seething disloyalty.

One day at Barrackpore, which is sixteen miles from Calcutta, a low caste Indian asked a Brahmin sepoy for a drink of water from his brass pot. The Brahmin refused on the ground that the low caste man would defile his pot.

"You are already defiled," said the man to the Brahmin, "by biting cartridges which have been greased with cow's fat."

As a matter of fact, none of the offending cartridges had yet been served out to the men, and if this had been explained promptly and the men

told that they would be allowed to grease the cartridges in their own way, the excitement would probably have died down.

It was only after long delay that the military authorities explained the facts, and by that time the story had taken too firm a hold of the native soldiers for any contradiction, however plausible, to be believed.

Rumours went round that the Governor-General wanted the sepoy troops to conquer Persia and China as, according to their own ideas, they had already conquered India for the British, and as a preliminary, they believed, he was going to destroy their caste. The story of the greased cartridges travelled like wildfire all over Northern India.

In February, 1857, some native infantry from Barrackpore arrived at Berhampore, 120 miles away, and told the story of the cartridges to their comrades of the 19th Native Infantry, with the result that when cartridges were served out to these men they refused to receive them, seized their weapons and shouted defiance.

Unfortunately there were no British soldiers at Berhampore, and the colonel in command was rather doubtful as to whether his native cavalry and artillery could be relied upon to act against the mutinous infantry. But after some explanation and remonstrance the sepoys laid down their arms and returned to their lines.

An Ugly Situation

Lord Canning, the Governor-General, on learning what had happened at Berhampore, resolved to take action. Knowing that some European troops were on their way to Calcutta, he ordered that the mutinous 19th Regiment of Sepoys should be marched to Barrackpore to be disbanded. This news excited the sepoys already at Barrackpore, who sympathised with their mutinous comrades, and one of them named Mungul Pandy swaggered about the lines with a loaded musket in his hand calling upon his comrades to rise, at the same time threatening to shoot the first European that appeared.

"Turn out, all of you," he shouted, "the English are upon us. Through biting these cartridges we shall all be made infidels."

News of what was going on was carried to the English adjutant, Lieutenant Baugh, who at once rode to the parade ground followed by his European sergeant and a Mohammedan orderly. Mungul Pandy fired at him and wounded his horse, which brought Lieutenant Baugh to the ground.

Baugh, much shaken, scrambled to his feet, and fired but without effect, and thereupon Mungul Pandy cut down the lieutenant with his sword. The sergeant rushed up, calling on the orderly to help. He tried to seize Mungul Pandy, but he too was cut down.

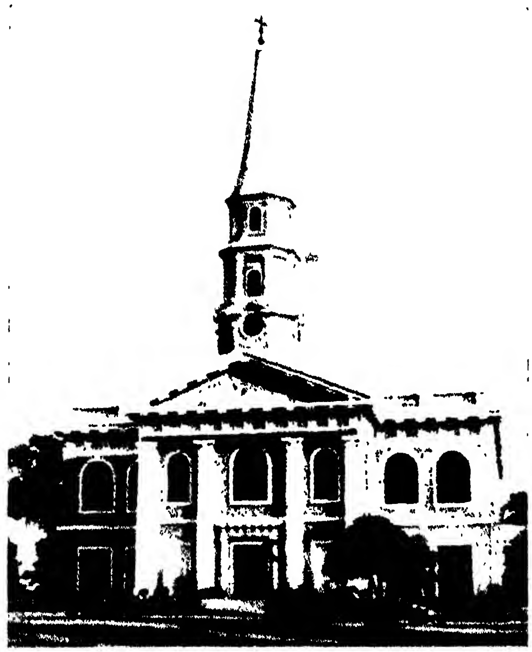
By this time the colonel with several other British officers had come up and ordered the men of the guard to seize the mutineer, but the native officer told him that the men "would not go on." At this the colonel appears to have been nonplussed.

But at that moment the brigadier, General Hearsey, rode up to the parade ground with his two sons, and someone called out "Have a care, his musket is loaded." The general cried out angrily that he cared nothing for the musket, and telling his son, "If I fall, John, rush in and put him to death somehow," drew his pistol, pointed it at the head of the native officer, and ordered him to take his men forward and seize the mutineer.

The sepoys were for the moment overawed by the general, and did as they were ordered. Mungul Pandy tried to shoot himself, but failed and was arrested. A few days later he was tried with another mutineer and convicted and hanged.

This incident may almost be regarded as the beginning of the Indian Mutiny. At any rate, it should have shown the authorities the danger of the discontent that was seething in the native regiments.

The British officers in command in India at this time seem to have been of two classes. There were those who knew how to act promptly and fearlessly, and there were those who, partly through trust of their native soldiers and partly through indecision failed to deal with the dangerous situations as they arose. More of the former type, and there would probably have been no Mutiny; more of the latter type, and India might have been lost for ever.



The English church at Meerut, which the officers were attending when the Mutiny broke out

What firmness and decision could do was shown by Sir Henry Lawrence, the Chief Commissioner, at Lucknow. A native regiment of infantry broke out into mutiny, and threatened the European officers. Lawrence at once ordered a British regiment and a battery of eight guns manned by Europeans, with four sepoy regiments, to proceed to the lines of the mutineers some miles away. The mutineers were taken by surprise. They suddenly saw infantry and cavalry on either side of them and a row of European guns in front. When ordered to lay down their arms they obeyed, and then, seized with panic, rushed away in the darkness.

They were pursued, and most of them arrested by the native infantry and cavalry. These sympathised with the mutineers, but fear of Lawrence compelled them to obey.

A mutinous regiment at Barrackpore was disbanded, and it was thought that there would now be little more trouble.

But within a week a real outbreak occurred at Meerut, an important military station only forty miles from Delhi. This is generally regarded as the real beginning of the Indian Mutiny. It set Northern India in a blaze, but had there been a man of Henry Lawrence's type the rebellion might have been scotched before it could do the untold harm that soon resulted.

Gaol for Mutineers

There had already been signs of insubordination at Meerut, when 85 men of a sepoy cavalry regiment refused to receive cartridges, even of the old type. They were at once arrested and tried by a court-martial of native officers, who found them guilty and sentenced them to imprisonment, but with a recommendation to mercy.

General Hewitt, in command of the district, saw no reason for extending mercy, except in a few cases, and the men, after being paraded and stripped of their uniforms, were loaded with irons and sent to gaol under a native guard.

The next day was Sunday, May 10th, a particularly hot day, and as the church bells rang out calling the British from their quarters to evensong, the men of the 3rd Native Cavalry, according to a prearranged plan, broke from their barracks and, brandishing their sabres, galloped to the gaol and released the mutineers. The sepoy infantry at the same time ran to their lines, arms in hand, and fell into ranks under their native officers.

In the European quarter all were blissfully ignorant of what was going on, till a British sergeant, rushing to Colonel Finnis of the 11th Sepoy Infantry, shouted "For God's sake, sir, fly, the men have mutinied!"

But Finnis was not the kind of man to fly. Gathering several British officers, he rode at once to the lines, and

with appeals and threats kept the native regiments steady, hoping that in a moment or two the British dragoons and artillery would sweep down upon the scene and overawe the men. Close by stood the men of the 20th Sepoy Regiment, and they too were kept in line by the entreaties and remonstrances of their officers.

For a solid hour twenty or thirty Englishmen kept 2,000 mutineers from breaking loose, listening anxiously all the time for the trample of hoofs and the rumble of guns which should announce the arrival of the European artillery from the British quarters.

But General Hewitt has not unfairly been described as " an ass commanding an army of lions." There were fatal delays, much valuable time being lost in an idiotic and unnecessary roll call. The men should at this time undoubtedly have been hurrying to the native lines, but owing to their non-appearance the mutiny became a revolt.

The native infantry fired on their officers, who fell riddled with bullets and then the sepoys broke loose and with the 3rd Native Cavalry went off committing arson and murder in the European houses. The mob joined the soldiers, and that quiet Sunday evening was changed into an Armageddon.

Every European man, woman and child who fell into the hands of the rebels was killed with terrible cruelty, and yet close by were 2,200 British troops who could have been led by General Hewitt to put down the revolt.

Instead, these men were kept idle while the revolting rebels, with their arms and ammunition, set off on their way to Delhi to proclaim the old Mogul King as sovereign of Hindustan.

There were no European troops at Delhi, and unhindered the mutineers from Meerut reached that city and were joined by the sepoy regiments there.

It was not till a fortnight after the outbreak that a party of British cavalry left Meerut to suppress some plunderers in the neighbourhood. As a historian, Dr. W. H. Fitchett, says: " A battery of galloper guns outside the gates of Delhi might have saved that city. It might, indeed, have arrested the Great Mutiny. But all India waited, listening in vain for the sound of Hewitt's cannon.

" The divisional commander was reposing in his armchair at Meerut; his brigadier was contemplating the regulations, Section XVII, and finding there reasons for doing nothing, while the mutiny went unwhipped at Meerut and was allowed at Delhi to find a home, a fortress, and a crowned head. It was rumoured indeed, and believed for a moment over half India, that the British in Meerut had perished to a man. How else could it be explained that at a crisis so terrible they had vanished so completely from human sight and hearing ? "

The Rebels Gain Ground

It was early on the morning of May 11th that the mutinous sepoy cavalry arrived at Delhi. They dashed across the bridge into the city, slew all the English they could find, including little children, and then galloped to the palace, declaring loudly that they had slain all the English at Meerut, and had come to fight for the faith.

About two miles from the city on a rising ground known as the Ridge was situated the British cantonment, but at this time there were no British troops encamped there. The few British officers in Delhi did their best to hold back their sepoy regiments from breaking into open revolt, anxiously waiting for the English troops they expected would soon arrive from Meerut. But, as we know, they waited in vain. Delhi, it should be explained, was garrisoned only by native troops, although there was in the city a huge store of munitions of war of all kinds.

The well at the Cawnpore barracks which gave the only water supply to the besieged English during the attack by the mutineers

How the Magazine was Saved

The greatest danger was that the vast stores of munitions in the magazine would be captured by the rebels. It had only a handful of Englishmen to defend it, nine in all, with Lieutenant Willoughby in charge.

Willoughby closed and barricaded the gates of the magazine and placed loaded guns in position to cover these. There were ten guns, but only nine men to work them. He armed a number of natives, but these, as he knew only too well, could not be relied upon.

Sooner or later the magazine must fall, so Willoughby ran a fuse into the building, broke open a number of barrels of gunpowder, strewed their contents about and heaped it on the end of the fuse. The other end of the fuse was carried into the open air, and one of the Englishmen named Scully stood beside it with lighted port-fire in hand, ready to blow up the magazine.

When the rebels attacked the magazine the guns were to be worked as long as possible, but when at last the sepoys swept into the enclosure, Willoughby was to give the signal by waving his hat and Scully was then to light the fuse.

An order in the name of the King of Delhi to surrender was indignantly rejected by the English guards, and then the sepoys hurried forward to the attack, firing as they came. At the first shot the natives inside the magazine scrambled over the walls and escaped, while the heroic nine were left alone to defend the store.

At last a gate was forced open, but as the assailants rushed forward they were swept by grapeshot from one of the guns and driven back.

One after another the brave defenders dropped, and at last Willoughby gave the signal to Scully. The fuse was lighted, the fire ran along, and then there was a tremendous crash like the blowing up of a volcano, a column of smoke and fire rose far into the sky, and the magazine, with its store of munitions, was destroyed.

None of the defenders had expected to escape, but Lieutenant Willoughby and three others managed to get away, though Willoughby died of his injuries a few weeks later.

Fifty Europeans—men, women and children—had barricaded themselves in a house in the city, but this was stormed and the captives were dragged away and locked up in an underground dungeon where they were nearly stifled. Then they were brought out, roped together, and murdered, the heir-apparent of the King devising special forms of cruelty for the occasion.

It is a matter of great satisfaction to know that a brave young English officer, Hodson of Hodson's Horse, months afterwards shot this vile princeling with some of his friends in the presence of 6,000 natives, explaining that they were the murderers of women and children.

By the evening of that day Delhi was in the hands of the mutineers who had gained a capital and a king.

This news spread rapidly throughout northern India, and before long an area half the size of Europe was in revolt. In many places the rebels killed their English officers, murdered the women and children, and went off to join the rebel army at Delhi.

The most horrible feature of the Mutiny was the treachery of the Indian natives in authority. At Jhansi, for example, garrisoned entirely by sepoys, the soldiers went about burning and murdering. A number of Europeans, however, including women and children, took refuge in the fort.

The Ranee of Jhansi, the widow of the former chief, was a woman who cherished a bitter hatred of the English because they would not allow her to manage the small principality. She sent guns and elephants to help the mutineers, but when the fugitives in the fort ran short of provisions the Ranee swore solemnly that if they surrendered without further fighting their lives should be spared and they should be conducted in safety to another station.

The rebel sepoys took the same oath, and relying on the word of these Indians the party surrendered. At once with vile treachery the whole 55 men, women and children—were seized and bound and then butchered in cold blood by the order of the Ranee.

But the most terrible story of treachery is that of Cawnpore, and no Englishman should ever forget it. This city, situated on the Ganges rather more than 50 miles from Lucknow, had been in the possession of the English for about half a century.

It had been an important military station, but since the conquest of the Punjab the European troops had been taken away, and the garrison consisted of four native regiments, numbering 3,500 sepoys. The only Europeans were the regimental officers with about 60 artillerymen, their wives and children, and a considerable body of civilians, engaged in trade.

The officer in command was Sir Hugh Wheeler, who had done good work in the East India Company's service, but was now over 70 years of age and was certainly not suited for a situation such as that which was about to arise.

When news of the outbreak at Meerut reached the sepoys at Cawnpore the men became excited, but General Wheeler and most of the other English officers seem to have had a blind faith in the loyalty of their men, which, as we look back, appears pathetic. Yet it is clear that the general did not altogether trust the native soldiers, for he decided that a place of refuge should be prepared for the European community in case the sepoys did revolt. But he selected the most unfortunate place in the neighbourhood of Cawnpore.

There was a magazine, covering three acres, with a high wall round it, strong buildings inside and a great store of guns and ammunition, with the river guarding one side and a ditch another. It would have been an ideal place for defence, with ample shelter for the women and the sick, of whom there were large numbers, and with an abundant supply of water.

A Foolish Choice

But Wheeler, for some reason which nobody has ever fathomed, ignored this place and selected for defence some old barracks which had once belonged to a European regiment on an open plain six miles away. There was no proper shelter, no adequate water supply, and the only defensive works consisted of an earth rampart which was hastily thrown up and which could be pierced anywhere by a musket ball.

So deluded was Wheeler about his beloved sepoys that as late as May 18th he telegraphed to Calcutta: "The plague is stayed: all well at Cawnpore."

Living at Bithoor about six miles from Cawnpore was the adopted son of an ex-Peishwa or hereditary ruler of the Mahrattas. His real name was Dhundu Punt, but he is known in history as Nana Sahib. His nominal father had received from the British Government a life pension of £80,000 a year, but the Government naturally refused to continue this to the adopted son, who had inherited at least half a million pounds from the ex-Peishwa. He was allowed to maintain semi-royal state at Bithoor and to keep guns and followers.

While pretending to be very friendly with the English he actually nursed a great hatred for them. He was a subtle dissembler. As soon as news arrived of the outbreak at Meerut on May 10th, the Nana professed his indignation at the mutiny, and repeated his declaration of attachment to the English. He offered to organise a force of 1,500 fighting men to resist the sepoys in the event of their mutiny.

Although General Wheeler had been warned that Nana Sahib was treacherous, he accepted his help and put him in charge of the treasury. As Dr. Fitchett says, "this was committing the chickens for security to the benevolence and good faith of the fox."

There was an alarm of trouble on May 21st, and it was thought wise that the European ladies with their families and all European non-combatants should proceed to the barracks. Partly to show their confidence in the sepoys, and partly to keep an eye on them, however, the British officers used of a night to go into Cawnpore and sleep near their men.

At last on the night of June 4th the mutiny broke out. The men of a cavalry regiment rushed to their stables, mounted, and then with shouting and firing galloped off to seize the magazine and loot the treasury. The other sepoy regiments followed them one after the other.

Some eighty sepoys, however, remained faithful and actually joined the British in their retreat to the barracks, fighting bravely with them for nearly three weeks.

The place on the river Ganges at Cawnpore where the English were treacherously massacred by the sepoys

On this very day, June 4th, a fleet of boats laden with English people from Futteghur started down the river for Cawnpore. They were all civilians, and included women and children. They had become suspicious of the sepoys, although General Goldie, the commander at Futteghur, and Colonel Smith, in charge of the regiment there, were absolutely confident of their loyalty, and were indignant that they should be distrusted.

News travels very rapidly in India, and the sepoys at Cawnpore soon heard that three boatloads of English were on their way. When the boats reached Cawnpore they pulled in to the bank, knowing nothing, of course, of the outbreak there.

Suddenly a crowd of mutineers rushed down upon them. They tried to hide in the long grass, but the sepoys set this on fire and the victims were driven out, scorched and half-naked. They were dragged off to the Nana Sahib's presence, where they were all ordered to sit down on the ground, the men having their hands tied and being placed behind the women and children.

Then files of soldiers were marched up, fired into the little band of men and killed most of them, finishing off

with the sword those that the bullet had not slain. Nana Sahib, like the brutal scoundrel he was, watched the whole terrible proceedings. The women and children were reserved for a worse fate.

At Futteghur the mutiny actually broke out on June 18th. The British garrison took refuge at a small fort, held it for nearly three weeks, then fought its way to the riverside and embarked in boats. One grounded, and its occupants were killed at once. The other boats were fired upon, their inmates being shot or drowned, and only one boatload escaped to Cawnpore, where all perished.

Meanwhile, what was happening to the English at Cawnpore? All who were found in the city were murdered, and then after burning and looting the mutineers started off for Delhi.

It would have been well for the English at Cawnpore if the rebels had continued their journey, but Nana Sahib had no interest in Delhi. He saw a chance of reviving the Mahratta Empire, with himself as king reigning at Cawnpore.

So Nana went after the sepoys and with promises and threats induced them to give up their march to Delhi and to return to Cawnpore. He was determined to exterminate the English He seems to have thought that with the force at his command it would not be difficult.

The Attack Begins

On the morning of June 6th, General Wheeler, who was now entrenched with the English community in the barrack enclosure, received a letter from Nana announcing that he was about to attack the position. The mutineers, however, seem to have been in no hurry to make the advance. As Captain Talboys Wheeler says: "They preferred booty to battle, and turned aside to plunder the cantonment and city." They did not spare the houses of their own countrymen, and they took cannon and ammunition from the magazine in readiness for the attack on the entrenchment.

By noon they had placed their cannon in position and opened fire. It was a terrible situation for the English. It was the height of the hot weather, a blazing sun poured down all the hours of daylight, and for nineteen days the garrison suffered under a raking fire from the sepoy positions.

One of the buildings in which the sick and wounded were housed was set on fire. Provisions ran low and there was insufficient water, even for the children. There were supposed to be two wells in the encampment, but one yielded nothing, and the other was open all the time to the fire of the sepoy batteries. Every drop of water had to be brought from it, and the sepoys concentrated their fire upon this little patch of ground.

A brave civilian, John MacKillop, insisted on being appointed "Captain of the Well," and for a week went backwards and forwards under the galling fire bringing water in a vessel for the wounded and the women and children, till at last he was killed. "He staggered a few paces mortally wounded," says Dr. Fitchett, "then fell, but held up with his dying hands the vessel filled with the precious fluid and begged one who ran to his help to carry it to the lady to whom he had promised it."

Before long the whole of the buildings were in ruins, and the men had to dig holes in the earth in which their wives and children could sit sheltered by planks from the terrible glare of the sun and the hail of bullets

The men at least had the excitement of fighting, but the position of the women must have been agonising. "Unshod, unkempt," says one historian, "ragged and squalid, haggard and emaciated, parched with drought and faint with hunger, they sat waiting to hear that they were widows." A number of infants were born during those terrible weeks.

The exploits of valour that were performed by the individuals of that gallant band of defenders are worthy to rank with the heroic deeds described in Homer's great story of the Trojan War.

woman was seen approaching the entrenchments with a note for General Wheeler

There was Captain Moore, an Irishman, who though wounded early in the siege, with his arm in a sling walked to and fro calmly amid the tempest of bullets cheering and leading the men against overwhelming odds "Wherever he had passed," says Sir George Trevelyan, "he left men something more courageous, and women something less unhappy."

There was Delafosse, one of the only four men who survived the siege. He had charge of three nine-pounder guns, and when one of the carriages caught fire and it looked as though the flames would explode the gunpowder, he crawled underneath the burning carriage, lay on his back and with his bare hands pulled away the burning timber and threw earth on the flames. And all this despite the fact that the sepoys, having noted the fire, turned all their guns on the spot. But such stories might be multiplied until a volume was filled.

The Gallant Women

The women were as heroic as the men. When in a sally eleven mutineers were captured and brought into the enclosure, every British man was needed, for a desperate fight was going on at the moment. A rope was therefore hastily passed round the wrists of the captured sepoys and they were put in charge of the wife of a private. Her name was Bridget Widdowson. Although she had little children of her own who needed attention, she stood sword in hand over the eleven mutineers, while they squatted on their haunches, not one of them daring to move. It is curious that it was only after Bridget's place had been taken by a male guard that the eleven sepoys escaped.

When the supply of cartridges ran out the women gave up their stockings for use in the making of new cartridges. The sepoys, who outnumbered the besieged by about thirty to one, made several assaults but never reached the line of earthworks.

There were many deaths among the British, but these were nothing compared with the loss of life among the sepoy besiegers. As the English perished they were buried in the dry well, which now has a monument built over it, with an inscription telling its tragic story. This is not the famous Well of Cawnpore of which we shall read later.

After three weeks the sepoys began to get a little tired of the siege, for their losses had been tremendous On June 25th a woman was seen approaching the entrenchment with a note for General Wheeler. She was a captive Englishwoman waiting to be killed, and Nana Sahib had sent her as a messenger with his note, which

promised to give a safe passage to Allahabad to all who were willing to lay down their arms.

Had there been no women and children the garrison would have spurned such an offer and attempted to fight its way through the rebels. It is a pity that the garrison did not remember what a native promise was worth. Nearly a century before there had been a treacherous massacre of English prisoners at Patna, but the position at Cawnpore was desperate, and the harassed men grasped at a straw. There was no hope for the women and children, the sick or the wounded, except by accepting Nana's terms.

Nana insisted that the evacuation should be effected that very night, but this the English would not agree to. Early on the morning of June 27th the movement began. One of the conditions had been that Nana should afford a safe conduct to the river bank, a mile off, provide carriages for the conveyance of women and children and sick and wounded, and furnish boats to carry the whole party, numbering 450, down the Ganges to Allahabad.

It was a sad procession. The men marched on foot, the women and children were carried on elephants and in bullock carts, while the wounded were mostly conveyed in palanquins

The Tragedy of Cawnpore

When they arrived at the river the fugitives were forced to wade through the water to forty boats, of a type known as budgerows, which had thatched roofs, and by nine o'clock the whole party was huddled on board and the boats were preparing to leave.

"Suddenly," says Captain Wheeler, "a bugle was sounded, and a murderous fire of grape-shot and musket was opened upon the wretched passengers from both sides of the river. At the same time the thatching of many of the budgerows was found to be on fire, and the flames began to spread from boat to boat. Numbers were murdered in the river, but at last the firing ceased.

"A few escaped down the river, but only four men survived to tell the story of the massacre. A mass of fugitives were dragged ashore; the women and children to the number of 125 were carried off and lodged in a house in the headquarters of the Nana. The men were ordered to immediate execution. One of them had preserved a prayer book and was permitted to read a few sentences of the Liturgy to his doomed companions. Then the fatal order was given; the sepoys poured in a volley of musketry, and all was over."

But worse was to follow. The women and children, with whom were joined those from Futteghur, making altogether just over 200, were huddled together in a couple of rooms.

On July 1st Nana Sahib went off to his palace at Bithoor, took his seat upon a throne, and was installed as Peishwa, while cannon roared out in his honour and at night the whole town was illuminated and fireworks were let off.

Then suddenly it was heard that English reinforcements under General Havelock were on their way to Cawnpore from Allahabad. Sepoy forces went out to meet them and suffered three defeats. Of the amazing exploits of this little British force, particularly of the gallant Highlanders, who marched and fought under the terrific sun in uniforms more fitted for Greenland than for India, there is no space to tell, but the story should be read by every Briton proud of his heritage.

The memorial that stands over the tragic well at Cawnpore the scene of the Mutiny's crowning treachery

The sepoy fugitives returned to Cawnpore, and then came the crowning atrocity of the Indian Mutiny. The cowardly scoundrel, in revenge, ordered the slaughter of the 200 women and children.

Every possible humiliation had been heaped upon them during their captivity. Each day two ladies were taken across to the Nana's stables and made to grind corn at a handmill for hours together. To the Eastern mind the crowning degradation of a defeated enemy is when his womankind grinds corn in the house of his slayer.

There were still alive several Englishmen, a couple of colonels, a judge, a merchant and his son, and a boy of fourteen. On the afternoon of July 15th Nana sent for these. They stood before him, and then at a nod from the Peishwa a line of sepoys levelled their muskets and shot down the half-dozen helpless victims.

Just before five o'clock that afternoon a woman from the Nana's household stepped inside the door of the building where the women and children were confined, and looking at them for a moment or two announced that they were all to be killed.

It was true, but even the sepoys shrank from such cowardly brutality. A messenger came and ordered them to fire through the windows upon the women and children, who were now praying. They obeyed, after some hesitation, and amid smoke and flame many of the poor captives were killed and wounded.

Then five men carrying swords went in and finished the dreadful work. It is too terrible to describe. Twice the sword of one of the men broke and he came out to get a fresh one.

The next morning the bodies, some showing signs of life, were dragged out and thrown into a well, while a crowd looked on. The dreadful spot is marked by a monument and an angel, with an inscription which tells the story of the Well of Cawnpore.

The Flag Kept Flying

It is a story that must never be forgotten so long as the Empire lasts. No wonder that when Havelock's Highlanders eventually reached Cawnpore they exacted a terrible vengeance for this atrocity. And who would dare to say they were not right?

It is the fashion, nowadays, for critics living in comfortable England to condemn many of the men who put down the Mutiny. But it is a pity they do not make themselves a little more conversant with the deeds committed by the natives on helpless women and children during the Mutiny itself.

There has been space to tell only a few incidents of this terrible outbreak, but what has been recorded was multiplied in scores of centres, and by June a great area of Northern India was ablaze with tens of thousands of well-armed rebels in control and only a few handfuls of British troops to resist them and keep the British flag flying.

The natives might well have thought the British power, in accordance with the prophecy that had been spread among them, had come to an end. But a few gallant men began at once to gather small forces to recapture the rebels' strongholds, and to win back to British allegiance the revolted areas.

It is a great story, and is told on page 1371 and the following pages. As we read the dramatic narrative we may well exclaim "There were giants in the Earth in those days!"

THE GREAT VALUE OF THE CRANK

Without the crank to turn to-and-fro motion into rotary motion we should be deprived of all sorts of useful machinery, not only on a large scale, but in such simple things as the grindstone and the sewing-machine. The crank is also used for changing the direction of motion, as in the old-fashioned bell crank shown on page 4. Here we read some interesting things about the crank and James Watt's ingenious substitute for it

The crank is one of the most ingenious adaptations of the lever that can be found, and it is used in all kinds of machinery, as, for example, in the sewing-machine, the lathe, the grindstone and the steam engine.

It really consists of a simple lever and takes various forms. In its most elementary form it is an iron axis with the end bent like an elbow, and is generally used for transforming reciprocating or to-and-fro motion into circular motion.

One of the simplest examples of this is the knife-grinder's machine, shown on page 4, and we can see the crank at work on any steam engine, such as a locomotive. It enables the piston, by means of a long connecting-rod which goes backwards and forwards as the piston is driven to and fro, to turn the big driving-wheels of the locomotive.

A single crank can be used only on the end of an axis, but sometimes it is necessary that the axis should be extended on both sides of that point where the to-and-fro motion is applied, and in that case, what is known as a double crank is employed. The engine of an ordinary paddle steamer furnishes a good example of the use of the double crank.

Who was the first man to invent this exceedingly useful device? We do not know. It is an old idea, which is constantly being adapted to new uses. When the steam engine was improved and made practicable by James Watt its employment for producing continuous rotary motion was one of its most useful applications. The older engines used for pumping had had only an up-and-down motion.

Watt, who was a very busy man, found that by applying the crank to the steam engine he could get the continuous rotary motion desired. The crank itself was old. It was found in every spinning wheel and grindstone and foot lathe in the country.

But while Watt was producing a crank engine at his works near Birmingham, a spying rogue gained information about it, made drawings and, rushing off to London, patented the stolen idea as his own. He had obtained the information from Watt's workmen chattering in a public house. Matthew Washborough was the name of the thief, and Watt was thus prevented from using his own idea.

Watt had not troubled to patent the idea himself, as he thought that the crank, being so old, would not be accepted by the Patent Office as a new invention when applied to the engine.

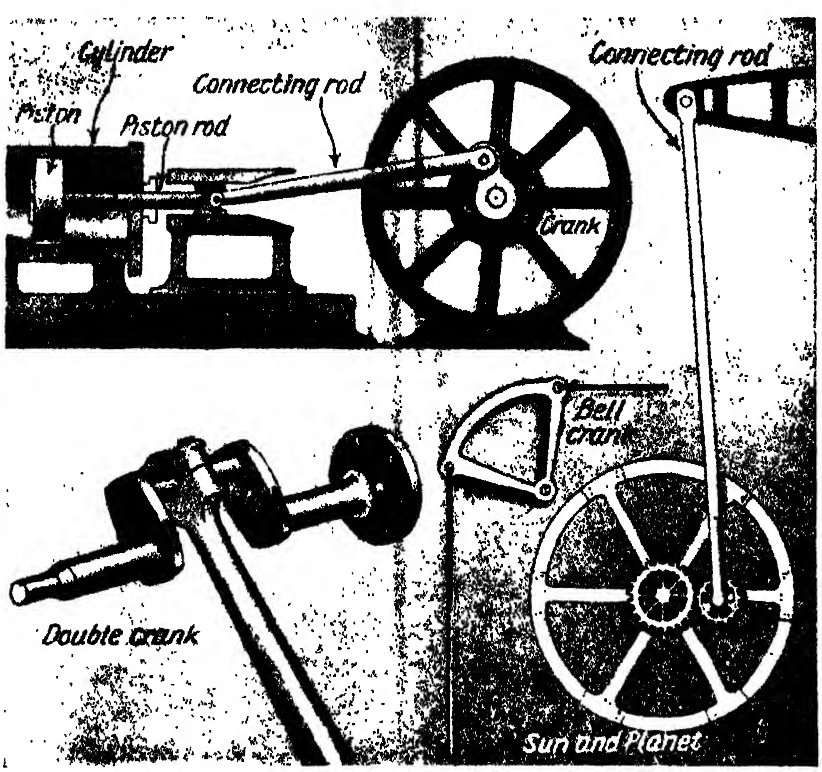
Washborough hoped that with the stolen patent he would be able to blackmail Watt into paying him a large sum of money for the use of the invention, but Watt, a man full of resource, immediately set to work and invented a new device for transforming to-and-fro motion into rotary.

This was known as the sun and planet motion. In this device there are two gear wheels, one being fixed on the axis of a flywheel and the other being fixed to the end of the connecting-rod of the piston. The latter does not revolve on its own centre, but moves round the other gear wheel.

As the connecting-rod moves to and fro the wheel on its end is carried round the circumference of the other toothed wheel, and when the motion of the connecting-rod is reversed a continuous rotary movement is produced by the momentum of the flywheel

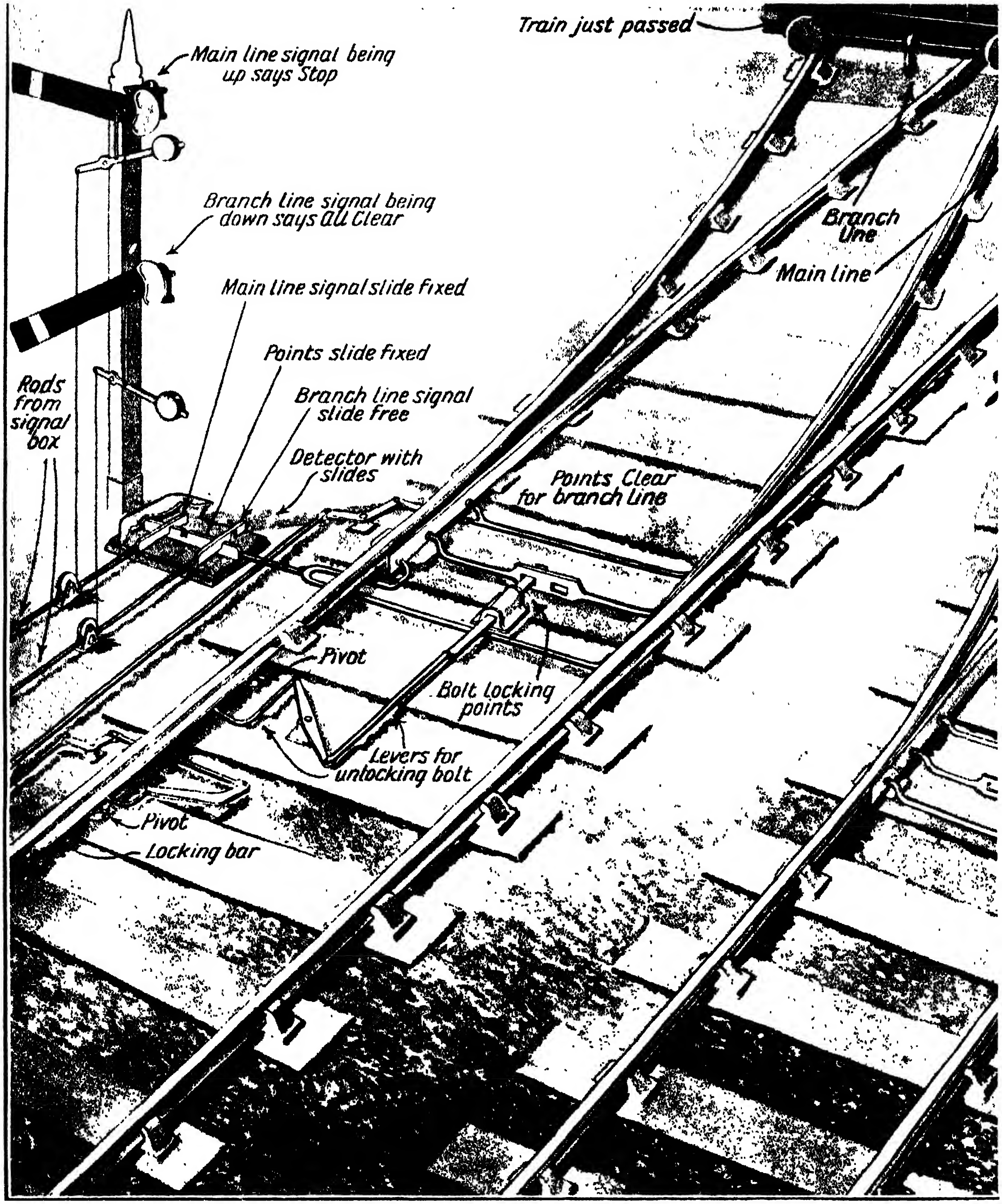
In some points the sun and planet device has an advantage over the crank, but owing to its higher cost in the first place and the fact that it is easily put out of order, it was supplanted by the crank

Watt's idea of applying the crank to the steam engine came while he was watching a lathe. In that machine the impulse given to the crank in the descent of the foot is continued in its ascent by the momentum of the wheel, which acts as a flywheel. Watt, unwilling to load his engine with a flywheel heavy enough to continue the motion during the ascent of the piston, proposed at first to employ two engines acting upon two cranks on the same axis at an angle of 120 degrees to one another



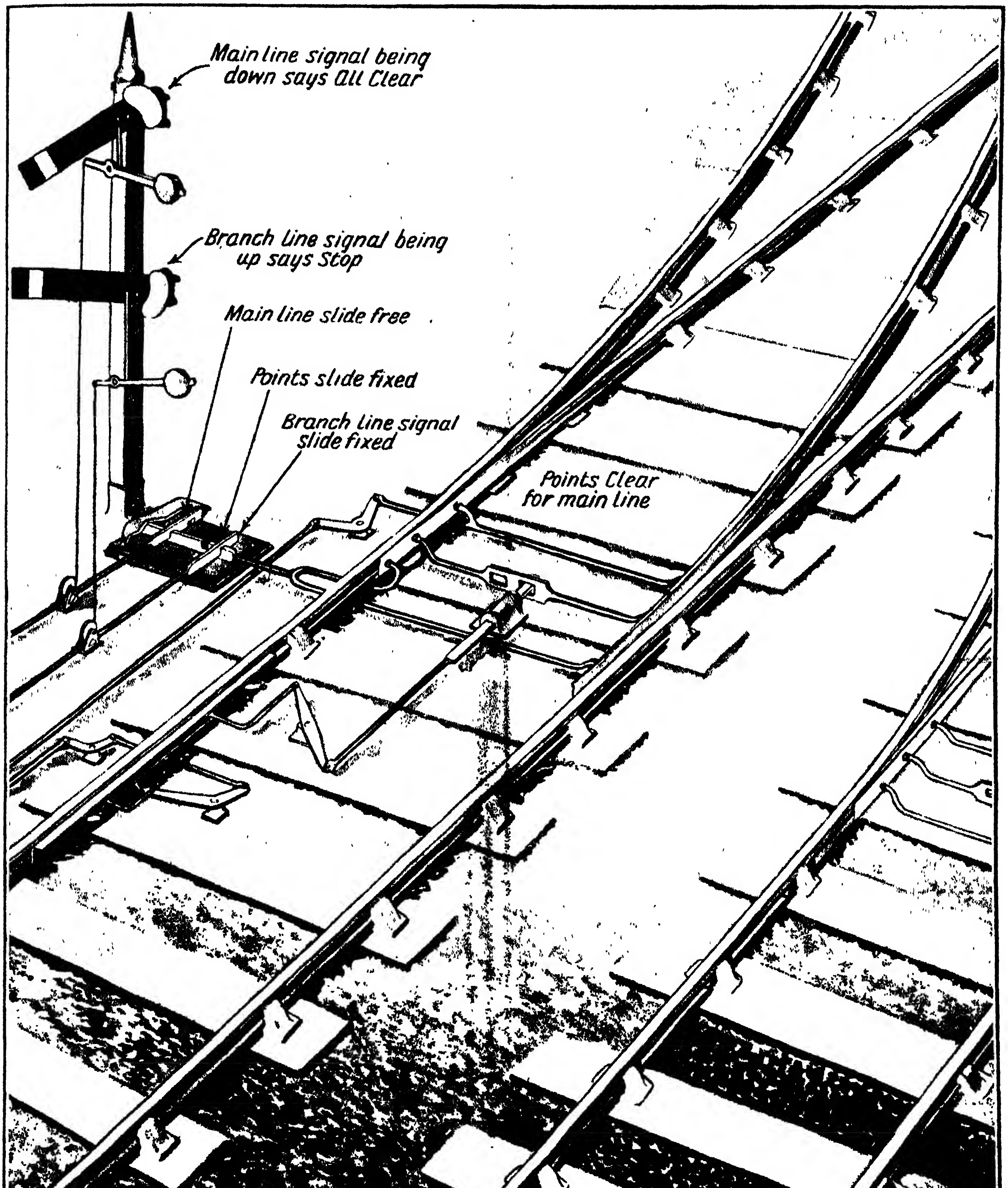
In the upper picture we see how the single crank changes to and fro motion into rotary motion, and at the bottom is shown the Sun and planet device which was James Watt's substitute for the crank. On the left is the double crank as used in the engines of paddle steamers, and in the middle the bell crank for changing the direction of motion

HOW THE POINTS ON THE RAILWAY WORK



These pictures show in simplified form how the points on the railway work, so that a train can pass straight on or be switched round into a side line. The signals and the points all work together so that by interlocking absolute safety is ensured. In the left-hand picture the points and signals are clear for the branch line, which turns off to the left, and a train has just passed over the points on to that line, the signal for the branch line, which is down, indicating that the line is clear. The main line signal which is the upper one, says "Stop," and it cannot be pulled down to clear the main line while the points are open to the branch line. This is because the slotted slides in the detector are fixed, as can be seen. Neither can the points be moved while the branch signal says "Clear," because the slides are interlocked and held fast. The signalman in his box, which is not shown, is about to switch over the points for the next train, which will run straight on along the main line. He pulls a lever which raises the branch line signal, and this moves the signal slide along, so that its slot is in the slot of the points slide, as shown in the right-hand picture. Next the signalman pulls a

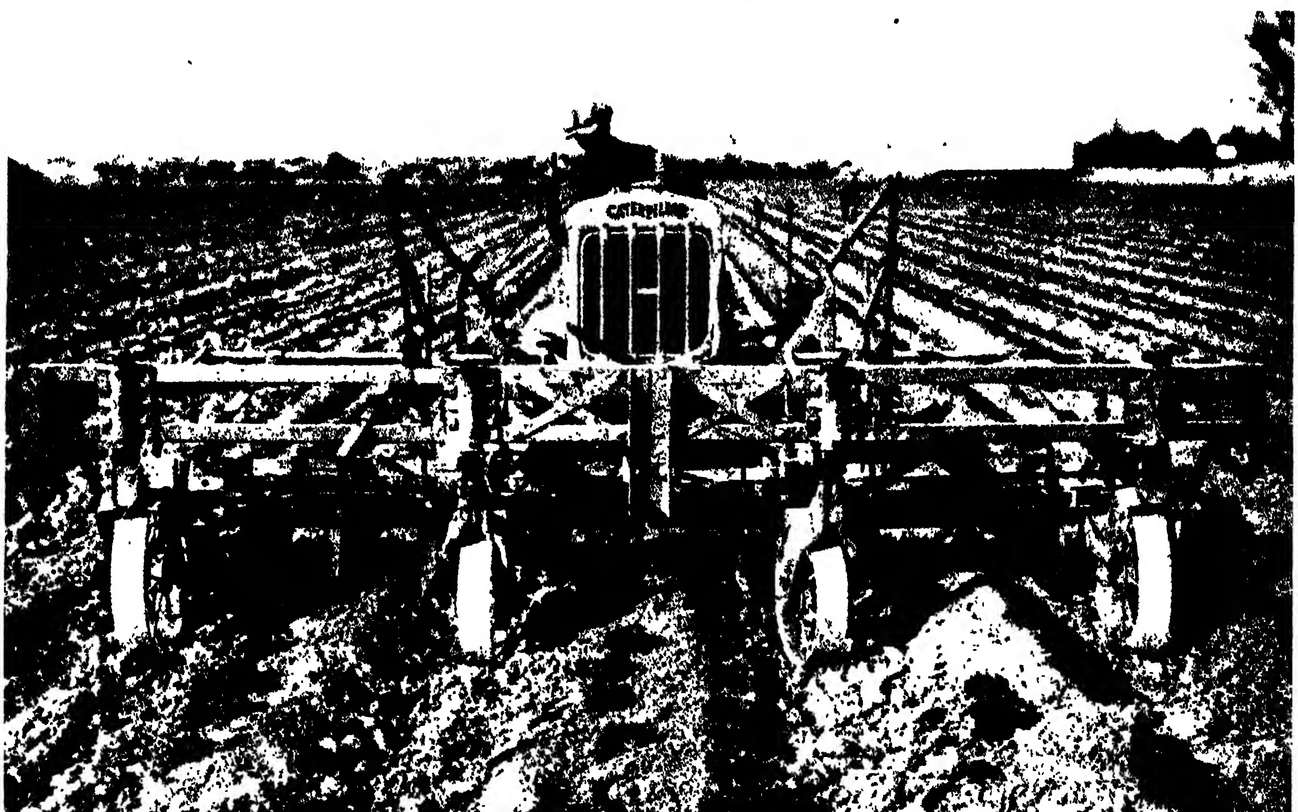
SO AS TO ENSURE SAFETY FOR THE TRAINS



lever which raises the locking bar, and by a series of levers withdraws the bolt of the points. The locking bar, which works up and down on pivots, is pressed down when a train is running over the line, which drives home the bolt more securely and locks the points firmly. The bolt having been withdrawn by the raising of the locking bar, the signalman can now pull over the points with his lever, and having done so relocks them with the locking bar as shown in the right-hand picture. He is now free to move the main line signal down, the slots being in such a position as to allow him to do so. The action is now complete, the points being in position for a train to pass along the main line. The main line signal in the right-hand picture stands at "All clear," while the branch line signal says "Stop." This branch line signal cannot now be moved to the "Clear" position because the points slide and the branch line slide are locked immovably. Neither can the points be moved so long as the main line signal says "Clear." The whole system is a very ingenious one. To make the explanation clear, the rails and rail-chairs have not been drawn to the correct scale in eitner of the drawings.

THE NEWEST MACHINERY IN THE OLDEST INDUSTRY

Agriculture is the oldest ot all industries, unless hunting can be called an industry. But though agriculture dates back to prehistoric times, and in its methods remained unchanged for centuries, it is now being mechanised like all other industries. The photographs on this page show the latest methods of breaking up the ground and uprooting the weeds so as to make the soil fit for the planting and rearing of crops. Here we see a caterpillar tractor pulling a four-bottom plough and breaking up the ground rapidly and efficiently. The old methods cannot compete with such machinery where farming is carried out on a large scale



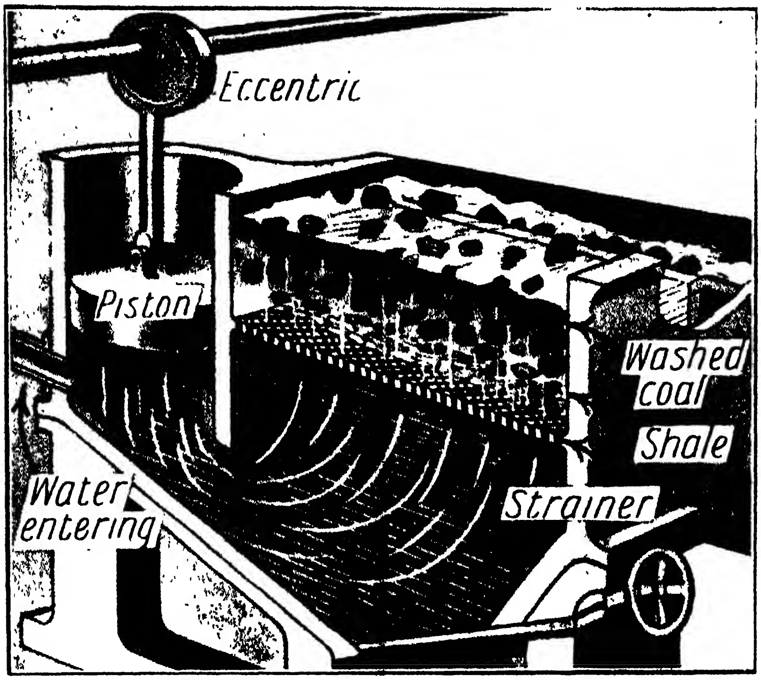
In this picture we see a machine known as a cultivator at work in a huge lettuce field in the Imperial Valley, California. The cultivator is driven by a caterpillar tractor, and as it passes between the rows of growing plants it uproots the weeds and banks up the earth at the sides of the plants Of course it is more difficult to use such machinery in a country like England, which consists of small farms, but even in Britain tractor-drawn machinery is displacing the horse-plough and the simpler tools worked by hand or horse power

MAKING THE COAL FIT FOR BURNING IN THE FIRE

When the coal reaches the mouth of the pit there is still a great deal to do before it is ready for burning in our grates. When it arrives at the top in trams or trucks, each tram is placed on a weighbridge and the weight carefully noted.

The tram, loaded with coal, is then caught by the fingers of an endless chain known as a creeper, which drags it up an incline, where it runs into a tippler, which is like a great iron cask. A lever is pulled and the tippler turns round, shooting the coal out of the tram on to a sloping screen below.

This screen consists of iron bars, and the larger lumps of coal roll down, the smaller pieces and the dust falling through between the bars. The large pieces drop on to what is known as a picking belt, an endless chain made up of iron plates fastened together. Men stand on each side of this belt and pick out impurities, like stone and shale. The men who do this have to be quick at their work, for the coal travels past them at a good speed. The clean coal then falls from the belt into a chute, and down into the railway trucks waiting to carry it away.

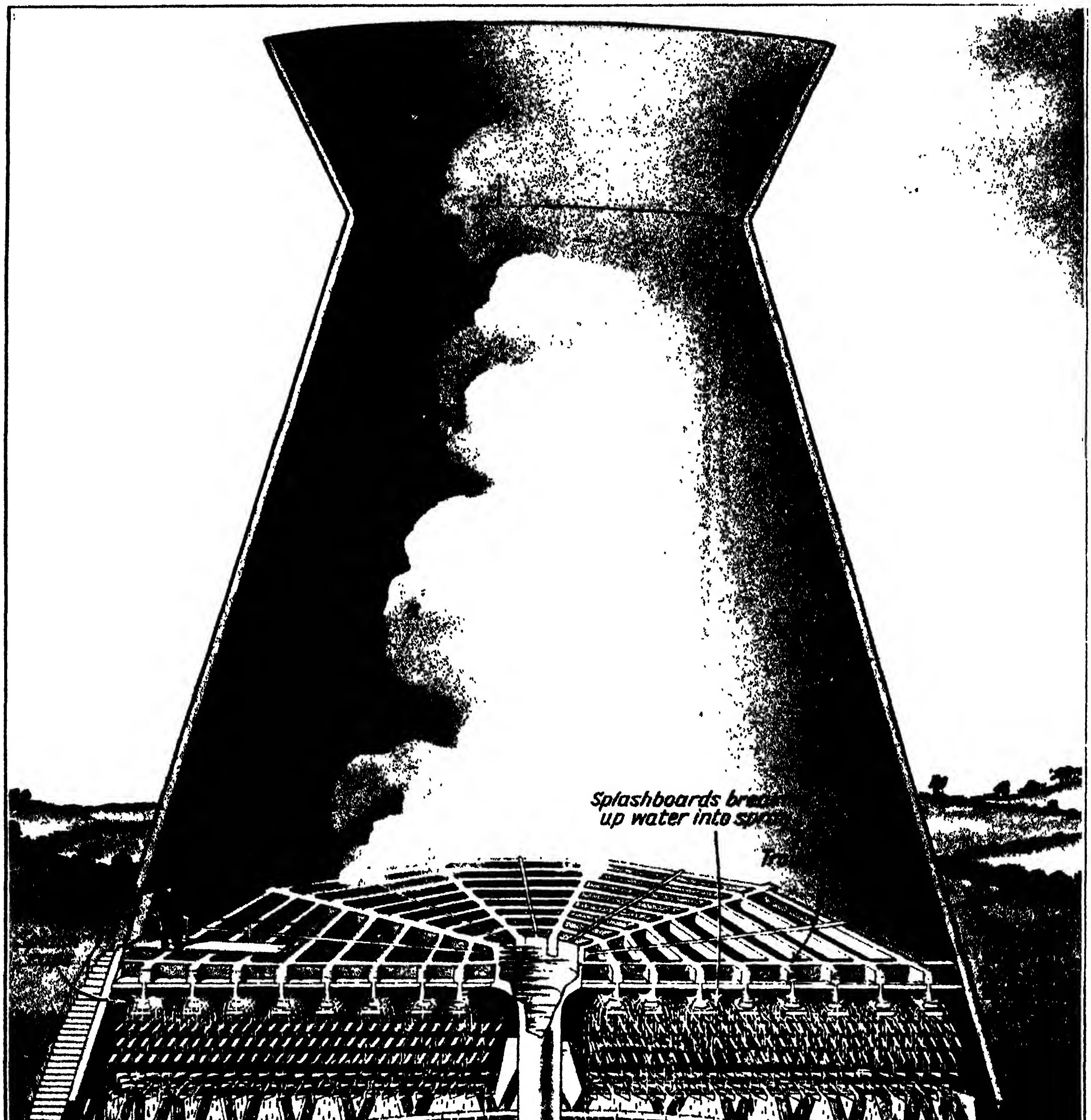


Here we see how small coal is washed. It passes into a trough with two compartments. On one side of the division, which does not reach quite to the bottom, is a sieve on which the unwashed coal falls. On the other side is a piston and as it works down it forces water under the division and up through the holes in the sieve, forcing up the coal and dirt. Then at the up stroke the water recedes, the shale and dirt fall quickly, and the coal being lighter is caught by the current and carried over the edge into another trough, as we see happening in the drawing

The smaller coal which fell between the bars of the screen is again passed over finer screens several times, and after the bigger rubbish is picked out the smallest coal of all has to be washed to remove from it impurities that could not be picked out by hand. The picture on this page shows the kind of apparatus that is used for this work. Without this cleaning process the coal as it comes from the pit would be a very unpleasant fuel.

In this photograph we see anthracite coal being carried on endless belts to a machine in which it is broken into suitable sizes, washed and graded at the rate of 15,000 tons a day. This is at a Pennsylvania mine. The man at the switches regulates the rate of travel to the hoppers. In America, where closed stoves are used, the domestic coal which is burnt is generally anthracite. This contains a much higher percentage of carbon than the bituminous coal used in England, which contains a good deal of gas. Anthracite burns slowly with very little smoke or flame, but throws out great heat

WHAT GOES ON INSIDE A COOLING TOWER



We shall have noticed at many of the great electric power stations tall concrete buildings in shape something like a railway milk churn. What are they for ? is the question many people ask. Well they are for cooling water, and are found only at those power stations that are away from rivers, and where water is expensive. Near rivers a constant supply of water can be obtained from the channel, but in other places the water must be used over and over again. The water which runs in pipes is used to condense the exhaust steam from the turbine engine so that it can be used again in the boiler for generating steam. Now the water in the pipes gets warmed by the surrounding steam, and must be cooled. This is done in the tower, to which it is conducted through a big pipe, as shown here. It runs into large troughs and thence into smaller ones, which are perforated so that the water can pass through. As it does so it falls on splash cups which spread it as a spray, and it afterwards drops down upon many stages of planking which still further break it up into spray. The air in the tower being warmed rises and cold air from outside rushes in at the bottom of the tower and cools the water now broken up into very fine spray. It then falls below into a reservoir and is conducted back to the condenser twenty degrees Fahrenheit cooler than it entered. One of these great reinforced concrete towers can cool as much as a million and a half gallons an hour. The water runs through the tower at the rate of six miles an hour. The towers have superseded the old wooden coolers

THE MARVEL OF THE ELECTRO-MAGNET

The electro-magnet is quite a simple device, but without it many of the electrical machines used every day would be impossible. It depends for its action upon a remarkable natural property of iron and was first put to practical use in 1820

We all know that we can change a bar of iron or steel into a magnet by stroking it in one direction with another magnet. It takes much longer to make the steel into a magnet than the iron, but, on the other hand, the iron loses its magnetism much more quickly than the steel.

Now there is another way in which we can change a bar of iron or steel into a magnet and that is by passing a current of electricity along a coil of insulated copper wire in the hollow of which the bar of iron is placed. This magnetises the bar more powerfully than any other method.

But there is a very curious thing about this. If the bar be soft iron, that is pure or almost pure iron, the bar will be a magnet only so long as the electric current is flowing along the wire. Cut off the current and the iron immediately ceases to be a magnet. On the other hand, if the bar is of steel it will become magnetised much more slowly, but when the current is turned off it will still remain a magnet.

This property of iron is of the greatest service to mankind. We have already seen on page 657 how valuable to us is the property of water which causes it to expand as it is about to freeze so that ice is lighter than water and floats in the liquid. Were it not for this the seas in the temperate regions would become frozen solid and countries like the British Isles would become ice-locked and uninhabitable.

Well, in the same way this curious property of iron, which causes it when pure to become easily magnetised and demagnetised and when it is hardened with a small portion of carbon to become permanently magnetised, though with more difficulty, is of untold value in electrical engineering. Without it our electric bells and telegraphs and many more elaborate machines would not work at all. We can see this in the case of the bell on page 120, and the telegraph instrument on page 292. The great magnets for lifting and loading masses of iron shown on pages 397 to 399 would be useless if the magnet could not be made and unmade at will by the turning on and off of the current as required.

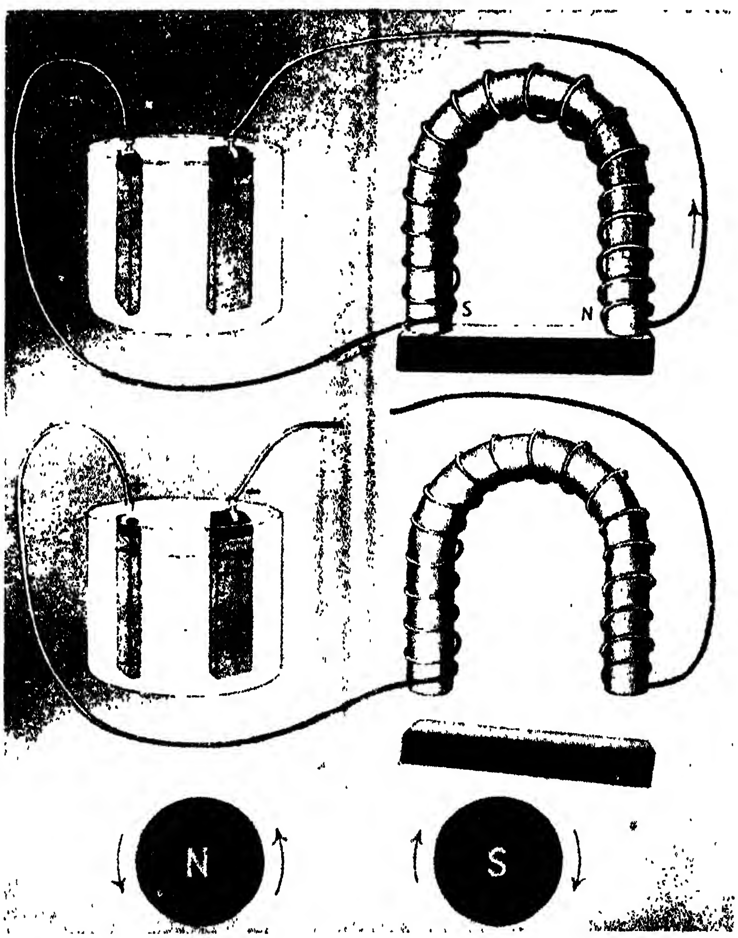
It was this discovery by Hans Oersted (1771-1851) of how to make the electro-magnet by passing a current along an insulated copper wire wound round an iron core that started the great science of electrical engineering and led to so many of today's machines.

William Sturgeon first used the name electro-magnet, and he did much to apply Oersted's discovery to practical uses. His first electro-magnet was in the form of a horseshoe, which was made from a rod of iron a foot long and half an inch in diameter. Round this he coiled a stout copper wire with only 18 turns.

When the current from a single electric cell was passed along the wire, the iron became a magnet strong enough to lift a weight of nine pounds. With a more powerful battery, however, the magnet lifted fifty pounds.

In addition to being under the control of the current, so that when the circuit is made the iron becomes a magnet and when it is broken the iron is demagnetised, the electro magnet has the further great advantage that it can be controlled from a distance by means of a key or switch.

In making an electro-magnet it is necessary to insulate the wire and to see that the iron that is to be magnetised does not touch the wire of the spiral, for in that case the current would short-circuit, that is, take a short cut through the iron from one turn of the wire to the next instead of going round and round the spiral. Some enormously powerful electro-magnets are now being made and used.



These pictures show the principle of the electro-magnet. When a bar of soft iron, either straight or bent into a horseshoe, is placed inside a coil of copper wire and a current is passed along the wire, the iron becomes a magnet, as in the upper picture. Directly the current is cut off, as in the lower picture, the iron ceases to be a magnet. Were it not for this the electric bell and the telegraph would not work. Which end of the magnet becomes the north pole and which the south depends upon the direction in which the wire is coiled round and the current passes. If we look at the north pole the current is always passing round anti-clockwise, and if we look at the south pole it is passing clockwise, as we see at the bottom of this drawing

A MISCELLANEOUS SET OF EASY EXPERIMENTS

On this page is described a set of experiments illustrating various scientific principles.

We have read in other parts of this book a good deal about action and reaction, and how they come into every department of our lives. Well, here is a very interesting and surprising experiment to show the power of reaction.

Take an apple and cut into it a little way with a knife so that the apple may adhere to the blade as shown. Then with a hammer give a short sharp blow on the knife blade. You will be astonished at the result, for the movement down of the blade as the hammer strikes it causes a reaction on the part of the apple in an upward direction, and in a moment the apple will be cut in two with a very clean cut through skin, flesh and core.

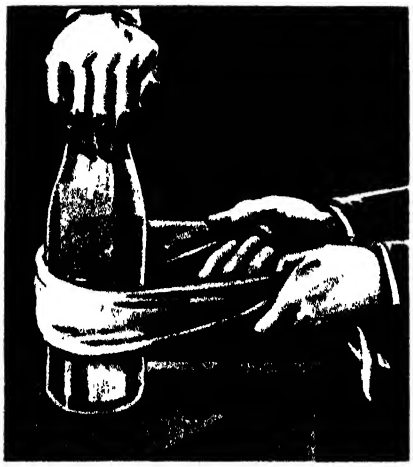
Here is an interesting experiment in the changing of the form of energy. We change mechanical energy into heat in this way. Fill a glass bottle with cold water. Then while someone holds it steady, place a duster or cloth round it and pull this to and fro rapidly, drawing it tightly against the glass. The friction of the cloth on the bottle will cause a great deal of heat which will very soon raise the temperature of the water inside.

Now an experiment to illustrate specific gravity. We take a long glass jar and fill it with water from the tap. Then we place in it an egg, which at once sinks to the bottom because it is heavier than the water. Next we take a length of glass or rubber tubing and place this in the jar so that the end reaches to the bottom. In the upper end we place the neck of a small funnel, and then pour gently into the jar some fully saturated brine, enough to occupy half the jar. This being heavier than plain water will remain at the bottom of the jar and the plain water will flow over the top of the jar. Because of this we should perform the experiment in the scullery sink. Then a strange thing happens. The egg being lighter than brine will rise to the top of it and remain floating in the middle of the jar where salt and fresh water meet.

Here is an experiment to show the power of suction. Cut a good-sized radish across the middle and press the cut surface down upon the centre of a tin or enamelled plate. Then lift the plate by the small end of the radish. The radish will hold the plate in the same way as a leather sucker adheres to a paving stone.

Next we will perform a simple electrical experiment. We cut out a number of very small butterflies and tie a thin silk thread to each. The other ends of the threads we fasten to a patch of sealing wax on a paper or card. Now we take a piece of thick brown paper, and after warming it lay it on a wooden table and rub it smartly in one direction with a clothes-brush or woollen cloth. This electrifies the paper, and if we hold it above the butterflies they will at once spring up to the brown paper, as shown in the picture on this page.

The last experiment is one in connection with sight. Hang up a small ring like a wedding-ring by a thread. Then take a straw by one end and, standing some distance away, pass the other end through the ring. This is easy, but now close one eye or bind a handkerchief over one eye, and it will be much more difficult to find the centre of the ring. We should try both eyes singly in turn. The experiment shows the great value of having two eyes and not merely one.

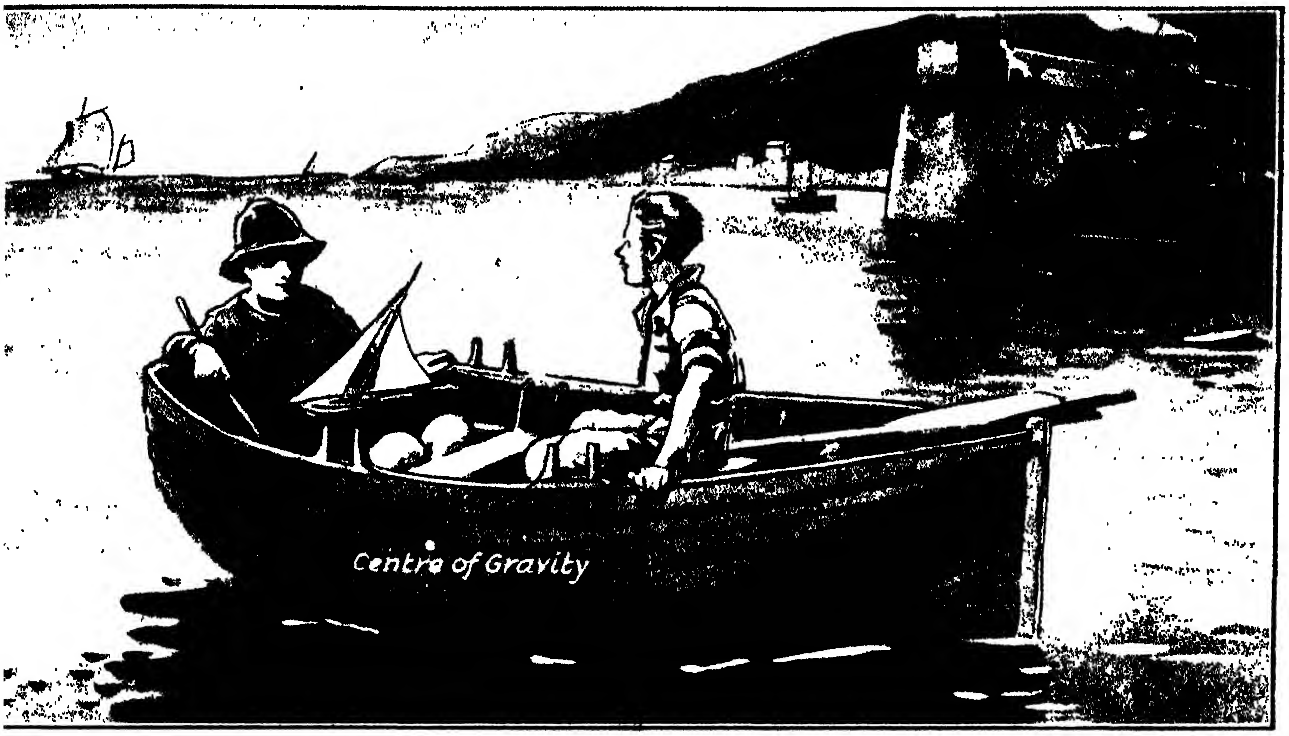


The first picture shows water in a bottle being heated by friction outside. In the middle is a novel method of cutting an apple in two, and on the right an experiment showing the great advantage which we gain from having two eyes instead of one

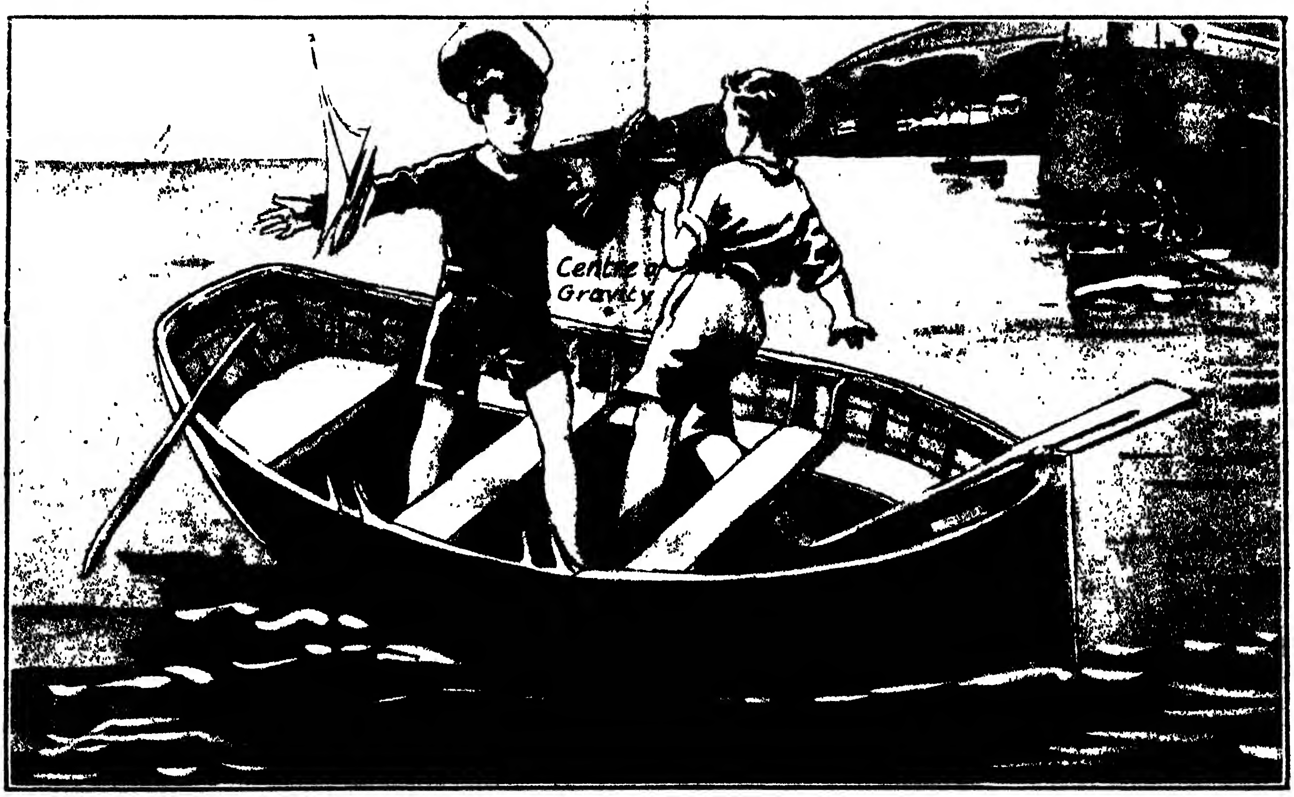


On the left is an experiment with an egg illustrating specific gravity. The next picture shows a radish holding up a plate by suction and on the right is an electrical experiment with paper butterflies on the ends of silk threads

WHY IT IS FOOLISH TO STAND UP IN A BOAT

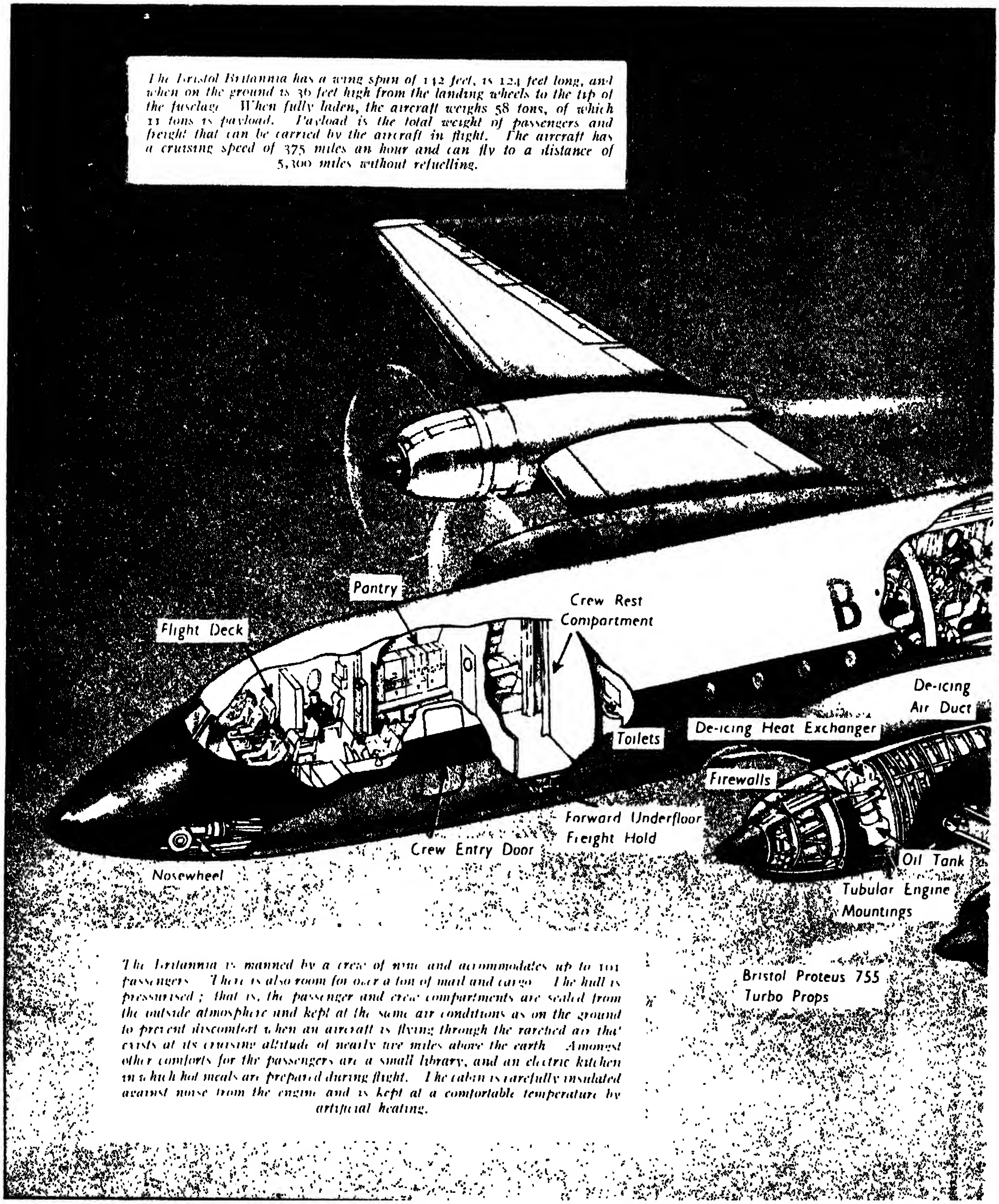


One of the most elementary rules taught to boys and girls who are learning to row is that it is dangerous to stand up in the boat, as, for example, to change places while on the water. The pictures on this page show the reason why we should not stand up in a small rowing boat. Here the boys are seated so that the bulk of their weight is kept low down. The centre of gravity, therefore, of the combined boat and boys is also low and the boat is in a position of stable equilibrium. We read about equilibrium on pages 33 to 35. A body is in stable equilibrium when its centre of gravity is low down and any slight tipping of the body tends to raise the centre of gravity



In this picture we see the boys standing up in the boat and, as can be easily understood, their action has thrown the centre of gravity of the combined boat and boys much higher than it was. The boat is now in a position of unstable equilibrium something like, for instance, a peg-top balanced on its point. The result is that the least jerk or movement will send the whole concern over, for the tendency of any object in unstable equilibrium is to fall over, lower its centre of gravity and come to a position of stable equilibrium

AIRLINER THAT USES JET ENGINES TO DRIVE

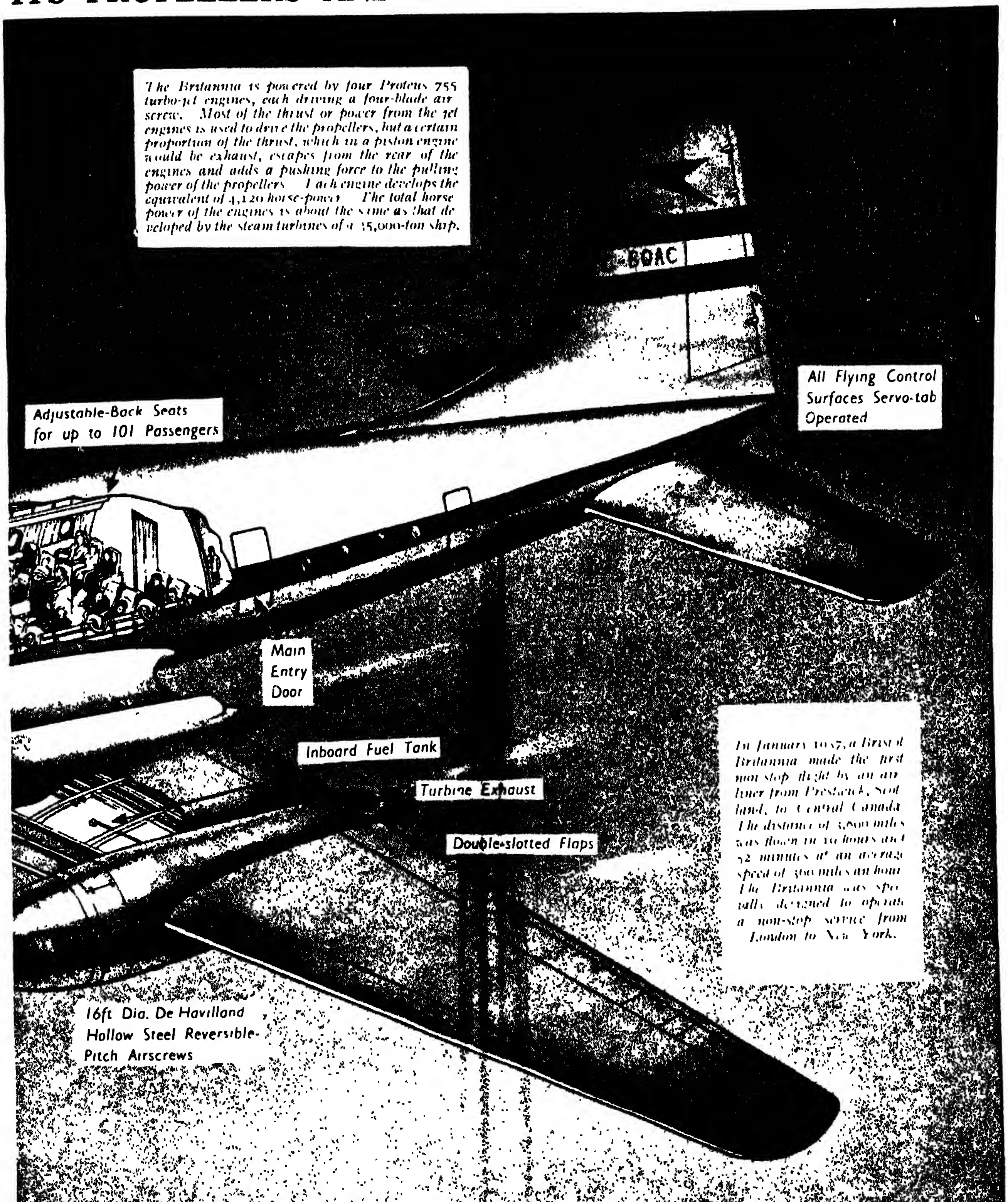


The Bristol Britannia has a wing span of 142 feet, is 124 feet long, and when on the ground is 36 feet high from the landing wheels to the tip of the fuselage. When fully laden, the aircraft weighs 58 tons, of which 11 tons is payload. Payload is the total weight of passengers and freight that can be carried by the aircraft in flight. The aircraft has a cruising speed of 375 miles an hour and can fly to a distance of 5,300 miles without refuelling.

The Britannia is manned by a crew of nine and accommodates up to 101 passengers. There is also room for over a ton of mail and cargo. The hull is pressurised; that is, the passenger and crew compartments are sealed from the outside atmosphere and kept at the same air conditions as on the ground to prevent discomfort when an aircraft is flying through the rarefied air that exists at its cruising altitude of nearly five miles above the earth. Amongst other comforts for the passengers are a small library, and an electric kitchen in which hot meals are prepared during flight. The cabin is carefully insulated against noise from the engine and is kept at a comfortable temperature by artificial heating.

Aircraft powered by turbo-jet engines, which depend upon the thrust of the jet stream for their forward motion, have to travel very fast and at an altitude of about eight miles if their engines are to develop their full efficiency. On the other hand, a propeller driven aircraft is efficient at comparatively low speed, but its power unit, if a piston engine, is complicated, and its pistons and other moving parts are subject to excessive wear and tear. Most of us might think that the speed and comparative simplicity of the jet aircraft would make it the obvious first choice for commercial aircraft. Contrary to popular belief, however, high speed is not always the most important factor in airline operation. Although jet-propelled airliners such as the De Havilland Comet 4, planned to go into service in 1958, can bestride oceans and continents at over 500 m.p.h., such speeds burn enormous quantities of fuel, and fares must be high if the jet air-liner is to pay its way; and no airline could make a profit by catering only for the comparatively few passengers willing to pay high rates for the privilege of flying at 500 miles an hour. With a view to compromising between the jet airliner and the piston-engined aircraft,

ITS PROPELLERS AND FLY AT 375 M.P.H.



British designers evolved turbo-propeller aircraft like the Bristol Britannia. The Britannia has ordinary turbo-jet engines, but with a propeller mounted on the front of each engine shaft carrying the compressor and turbine. In the ordinary jet engine, about two-thirds of the energy developed is used to drive the compressor through the turbine (as explained in page 248), and the rest is used for jet propulsion. With the turbo-propeller engine, the power developed at the compressor and turbine shaft drives a propeller. The surplus energy escapes through a nozzle at the rear to give an auxiliary push to the forward movement induced by the propeller. The Britannia's function is to operate on the same routes as the jet airliner, but at cheaper fares. Thus the Comet will carry 60 passengers a distance of 3,000 miles at a speed of over 500 miles an hour, whereas the Britannia carries 100 passengers a distance of 5,300 miles non-stop at a speed of 375 miles an hour. In other words, the Britannia can be compared with a fast 20-coach train travelling from London to Aberdeen, and the Comet with a non-stop ten-coach sleeper express maintaining a service between London and Edinburgh.

MYSTERY RAYS THAT BOMBARD THE EARTH

Throughout your life you are under constant bombardment from outer space; while you read this line of type, thousands of invisible bullets had travelled millions of miles to pass through your body. These invisible bullets are called cosmic rays because they come from somewhere as yet unknown in the cosmos, which is a Greek word meaning the universe or outer space.

But although scientists know that cosmic rays exist and have designed instruments for detecting their presence and intensity, very little is known about them. Despite endless research, the origin of cosmic rays is one of the great mysteries still to be solved by science

It has been found by means of special detectors that cosmic rays have tremendous penetrating power. Ordinary light penetrates only to a very small distance into opaque matter. Thus, a sunshade or a blind will stop most of the sun's rays from shining upon us, and a thin sheet of asbestos will shut them out altogether. Of course, X-rays and, as explained in pages 1125–1127, the radiation from atomic fission have a much greater penetrating power; but even the latter can be stopped by a wall of concrete.

On the other hand, cosmic rays will pass through a six-foot mass of lead. In other words, if you wanted to escape the bombardment of cosmic rays you would have to live in a house with roof and walls of lead at least 6½ feet thick. Cosmic rays continue their bombardment on the tops of mountains, in the frozen Arctic regions and in the hottest parts of the tropics.

Another curious fact about cosmic rays is that although they penetrate through millions of miles of space into the deepest mine shafts on the earth, they lose much of their penetrating power in water. When they strike the ocean, the rays do not penetrate to a greater distance than 100 feet; this is considerably less than the depth to which light penetrates in water.

Data collected by recording instruments carried into the higher layers of the atmosphere have proved that the rays become weaker as they approach the earth. It is indeed fortunate for us that the earth is surrounded by a fairly dense atmosphere able to absorb the cosmic rays and so greatly reduce their intensity.

If there was no atmosphere to absorb the greater part of the rays coming from outer space, our world would be a barren place on which no animal or plant could exist. Not only does the atmosphere reduce the effect of cosmic rays, but the earth's magnetic field acts upon them as a kind of regulator to measure out the amount we can receive without harmful effect.

Cosmic rays were discovered in 1893 by Professor C. R. Wilson, a Scots scientist who was studying the causes of the rings or halos of coloured light which in hilly districts sometimes surround a shadow thrown on mist lying on slopes below the position of the person shadowed.

As explained in the article on page 171, the halo is caused by the condensation of water vapour, and Professor Wilson proceeded to find out what caused the water vapour to condense. His experiments proved that most of the water drops were formed on dust particles in the air, but that a few of them appeared to be formed on electrified molecules of air called ions. Further experiments then suggested to Wilson that some other ions might be caused by a penetrating radiation that came from outside the earth.

About the same time, a German scientist named Gietel came to a similar conclusion, and in 1912 an Austrian scientist called Hess proved that such radiation existed by going up in a balloon and measuring it. He also found that the intensity of the radiation increased the higher he rose in his balloon. This suggested that the radiations were coming down from outer space, so Hess called them cosmic rays.

Scientists thereupon began to devote a great deal of attention to cosmic rays, and some remarkable discoveries have since been made.

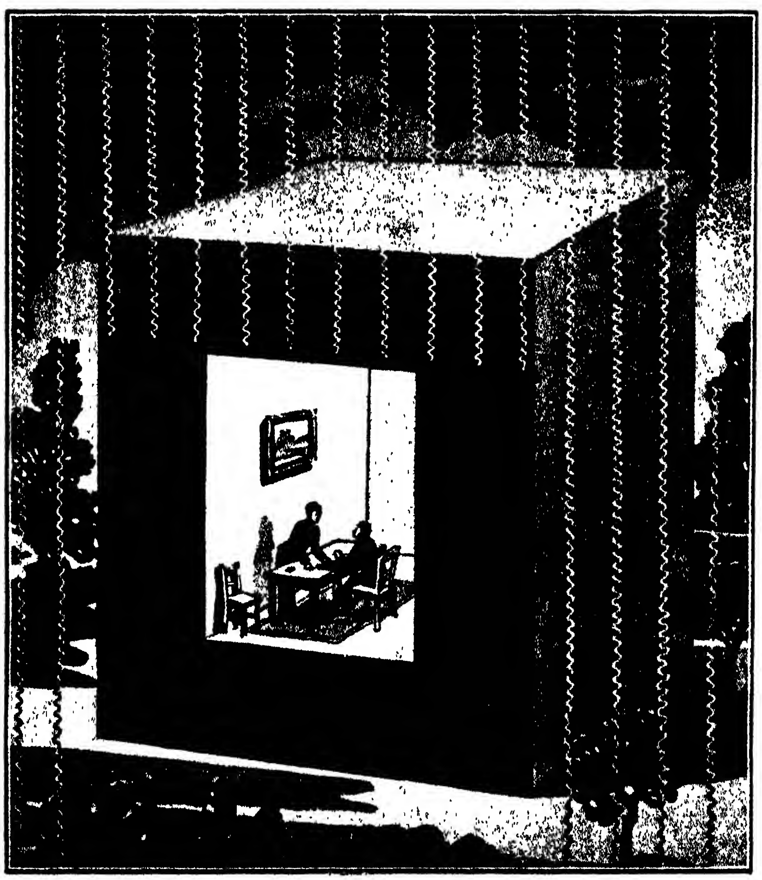
In the 1920s it was thought that the world and everything in it was made up from two particles of matter: the proton, which has a positive electric charge, and the electron, which has a negative electric charge. In 1932 Professor Chadwick was studying the radiation from radio-active elements and found a third particle, the neutron, which has no electric charge at all.

Then the scientists who were trying to solve the mystery of cosmic rays discovered that the rays contained two more particles. One of these was the positron, which does not exist on earth but is only created temporarily when light waves fall on matter.

The second particle found in cosmic rays was the meson, so called because its weight is believed to be between that of an electron and a proton. The electron is the lightest particle known, and the meson is about 200 times heavier, while the proton is about ten times heavier than the meson or two thousand times as heavy as an electron. Like the positron, the meson exists for only a fraction of a second.

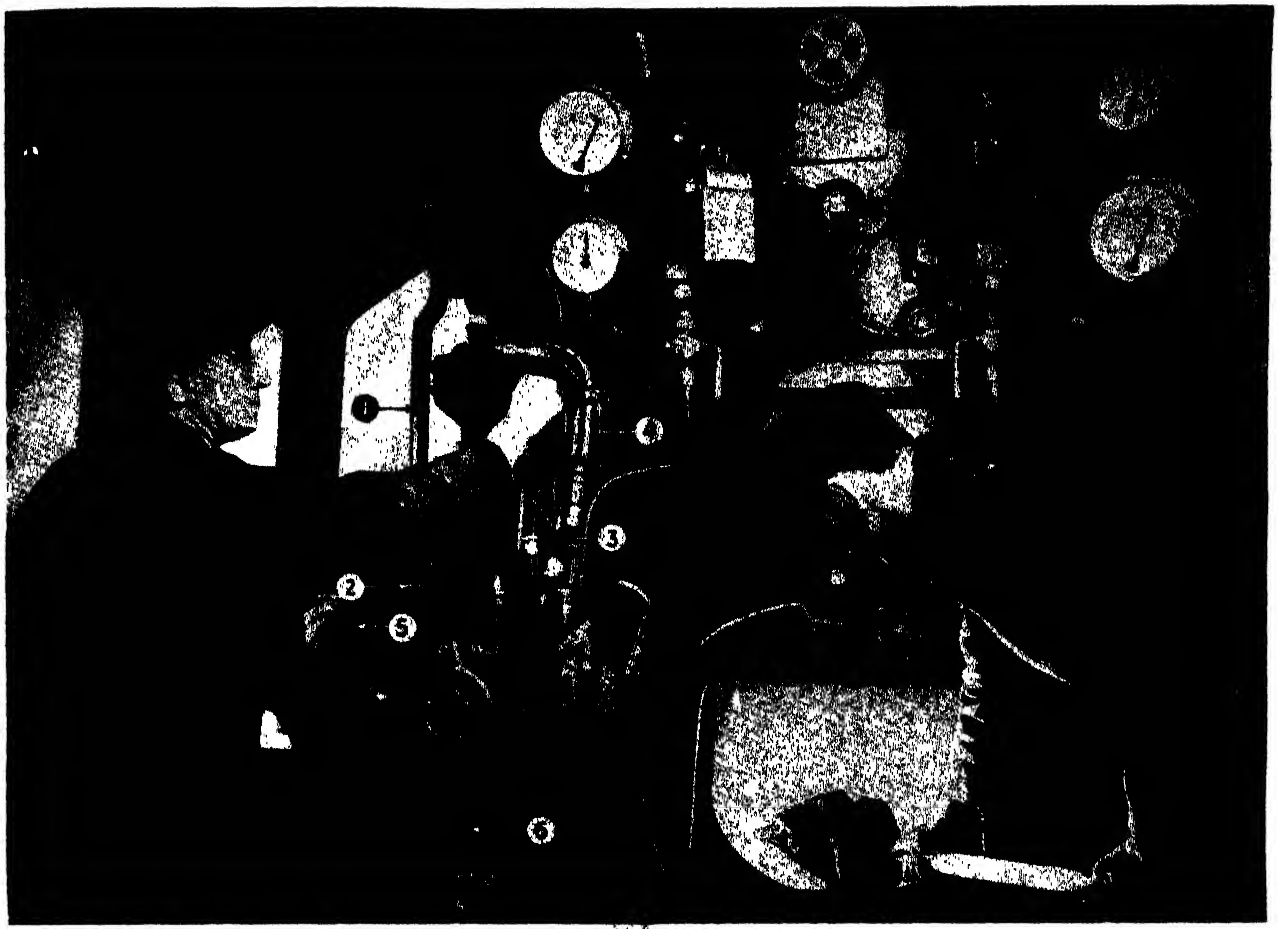
When speaking of the weights of particles, one must not think in terms of pounds or ounces, but in terms of lightness which are beyond our power to imagine. It is very much the same thing as measuring distance in thousands of light years; a light year is the distance light will travel in a year at a speed of 186,000 miles a second.

Even now scientists are not certain that the positron and the meson are the only particles in cosmic rays.



The mysterious cosmic rays which reach the Earth from all directions are exceedingly penetrating, and if we wanted to escape from them we should have to live in a room with walls, roof and floor made of lead 6½ feet thick.

THIS MAKES THE ENGINE WHEELS GO ROUND



If you are ever lucky enough to be invited on to the footplate of one of British Railways' Pacific type locomotives, this is what you will see. On the left sits the driver in front of the six main controls. 1, The regulator, which admits steam to the cylinders and has the same effect on the engine's speed as has the accelerator on the speed of a car. 2, The vacuum brake lever, which applies the brake on every coach making up the train. 3, The steam brake lever, which applies brakes on the engine only. 4, The whistle. 5, The reversing gear, which alters the "cut off," or period of steam admission. At high speed an engine works on "early cut off," and at low speeds on "late cut off"; if the wheel is moved far enough, the engine will travel backwards. 6, The sand lever with which the driver blows steam down a pipe and forces a spray of sand under the driving wheels, so giving them a grip when starting up on wet rails; there are two sets of sand pipes, one for forward and one for reverse running. At the right, behind the fireman, are the handwheels controlling the supply of water from the tender to the boiler. A sectional drawing on pages 1350-51 shows the chief outside parts of a Pacific locomotive and explains how they make the engine's wheels go round.

THE Pacific type locomotive is only one of the hundreds of different classes of engine running on British Railways. They vary in weight from forty to over a hundred tons, and the number of wheels may be four or fourteen. Some classes contain many hundreds of engines and others only one or two. The reason for the many different types is that the private railway companies, which were nationalised as British Railways in 1947, each built to their own design engines for every conceivable duty.

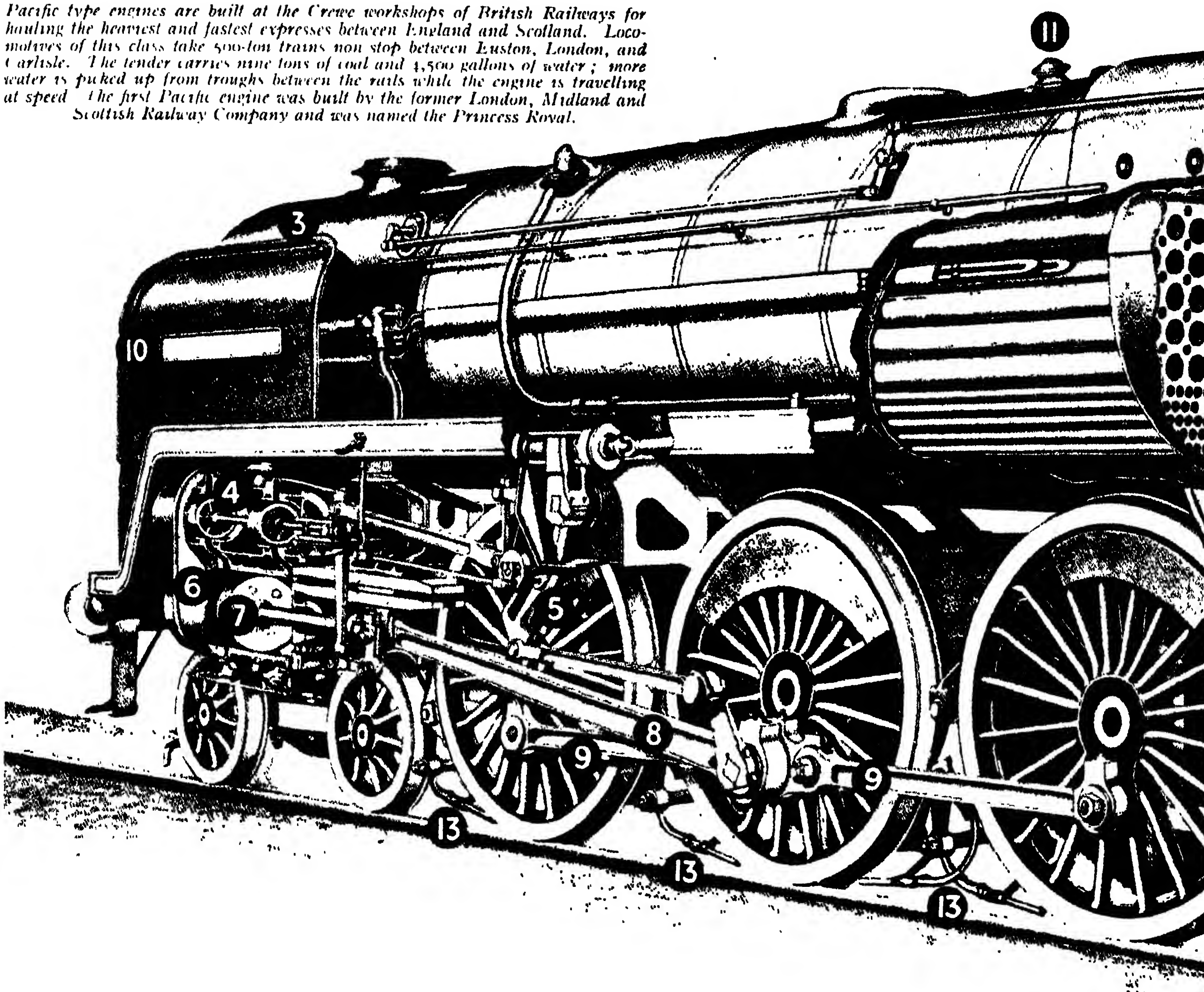
Operating so many different classes of locomotives made maintenance very difficult and expensive when all the chief railways in Great Britain came under a single authority, and British Railways has been steadily reducing the number of classes. Many of the new type locomotives that have come into service since 1950 are what are called mixed, that is, they can handle passenger and goods trains on most routes.

Every new British Railways locomotive is built to combine the best of the practices of the former companies, and it is intended that these practices shall be incorporated in some 20 standard classes. Most of the new engines put into service up to 1953 were steam driven but other kinds of motive power were introduced. Giant twelve-wheeled electric locomotives are working passenger and freight trains on the Southern Region, and on the West Coast route to Scotland diesel-electric engines are in service. The first gas turbine locomotive, which began running in 1951, resulted from experimental work with jet aircraft. Many people think that one type of engine should be able to haul any kind of train on any route. But locomotives must be designed for specific duties. A heavy freight engine needs small wheels so that the pistons, which turn the wheels and keep the train on the move, can be working quite fast when the train is travelling slowly. If the pistons did not work fast they would not be able to transmit enough power to the wheels to keep a heavy freight train on the move at all, however slowly. But an express engine must have big wheels to cover more ground on each stroke of the piston.

Ever since railways began, trains have been getting heavier and heavier, and more powerful engines have had to be designed to haul them. At first this was done by making the locomotives longer and fitting them with more driving wheels and bigger boilers.

But tunnels and bridges limit the size and weight of engines that can use the existing tracks, so engines of the same weight as before must be made more powerful. This is done by having higher steam pressures and more efficient furnaces to burn the coal that produces the steam.

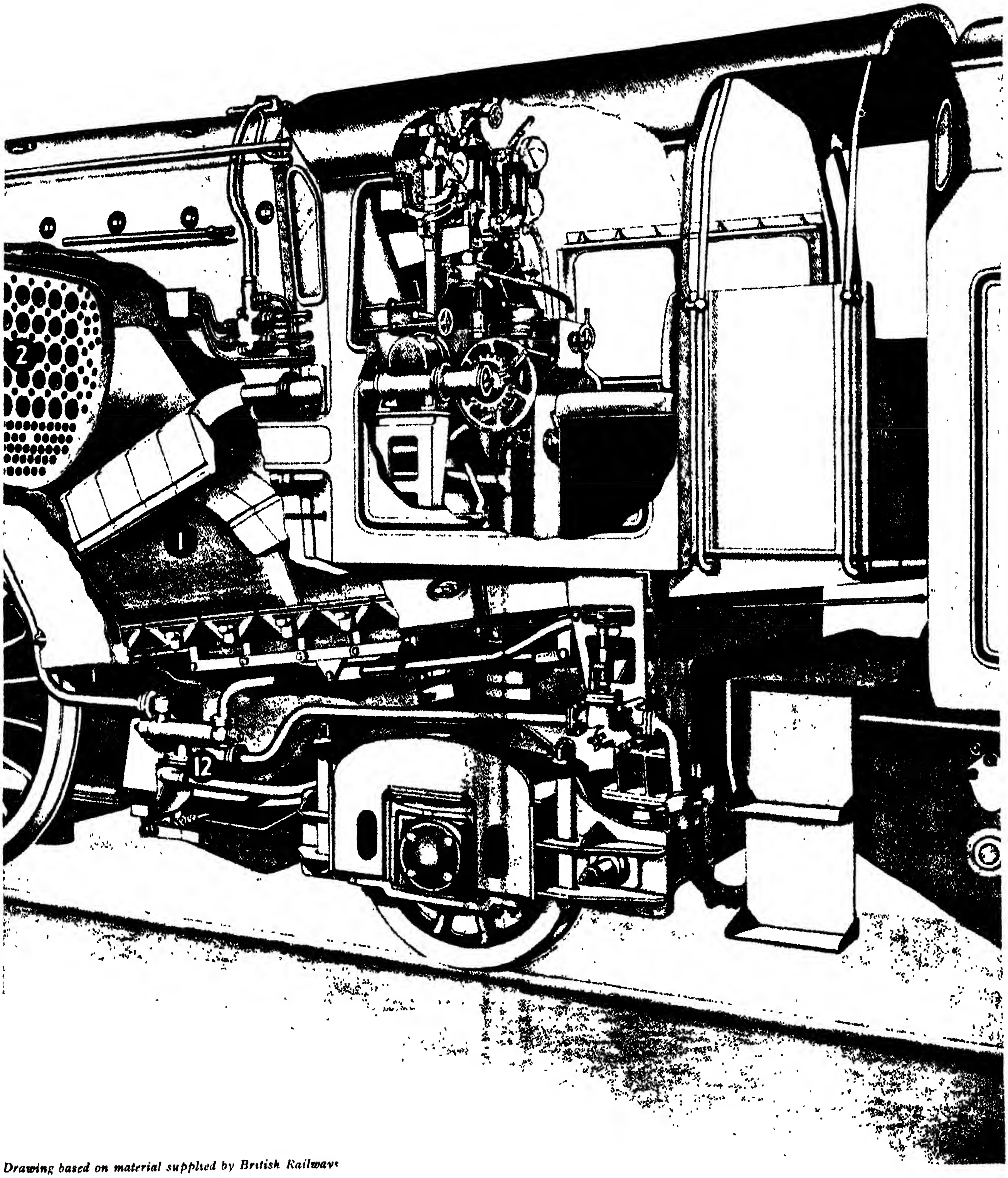
HOW BRITISH RAILWAYS' BIGGEST AND



Pacific type engines are built at the Crewe workshops of British Railways for hauling the heaviest and fastest expresses between England and Scotland. Locomotives of this class take 500-ton trains non stop between Euston, London, and Carlisle. The tender carries nine tons of coal and 4,500 gallons of water; more water is picked up from troughs between the rails while the engine is travelling at speed. The first Pacific engine was built by the former London, Midland and Scottish Railway Company and was named the Princess Royal.

In this picture diagram of a British Railways Pacific locomotive we see how an express engine works. Burning gases from the coal in the firebox (1) are drawn through the boiler tubes (2) to the smoke-box (3) and then out through the chimney. The water surrounding the tubes is turned into steam, and the steam, after it is "superheated" by being again passed through the hot flue gases, is led from the top of the boiler through the regulator to the steam chest (4). The valve, which is moved in the steam chest by the valve gear (5), admits the steam to the cylinder (6). The steam expands and forces the piston (7) along the cylinder. The piston is fixed to the connecting rod (8) and so makes the centre pair of wheels turn. The other two pairs are turned by means of the coupling rods (9). Other important parts shown on the drawing are: the smoke deflectors (10), to prevent smoke and steam from blotting out the driver's view of the road ahead; the safety valve (11), which allows steam to escape when the pressure in the boiler becomes too great; the injectors (12), which force fresh water from the tender (not shown here) into the boiler to keep the level correct; and the sanding pipes (13) for use when starting up on a slippery rail. The engine and tender weigh 158 tons 12 cwt., and together are 74 feet 4½ inches long. The cylinders, four in number, are 16½ inches in diameter, and their stroke 28 inches. The boiler tubes have a heating surface of 2,523 square feet, the fire-box 190 square feet, and the super-heater 370 square feet, making a total of 3,083 square feet. The steam pressure is 250 pounds per square inch and the area of the firegrate 45 square feet. Two of the cylinders are inside the frames over the leading bogie wheels and drive on to the leading coupled axle; while the other two, as can be seen in the drawing, are outside the frames and drive on to the intermediate coupled wheels. The bogie wheels are 3 feet in diameter, the coupled wheels 6 feet 6 inches, and the trailing carrying-wheels 3 feet 9 inches. The tractive effort of the locomotive, which represents the pulling power at starting, is 40,300 pounds. With four cylinders a great deal of steam is needed, and so there is a big boiler, with its greatest diameter 6 feet 3 inches. Inside the barrel are 16 steel super-heater tubes 5⅛ inches in diameter, and 170 steel boiler tubes 2¼ inches in diameter, all 20 feet 9 inches long and 7 feet 1 inch wide at the front, giving the grate area of 45 square feet. The smoke-box is 8 feet long and carries a chimney of new design. The regulator, instead of being in the dome, as is usual, is in the smoke-box, while what appears to be a dome

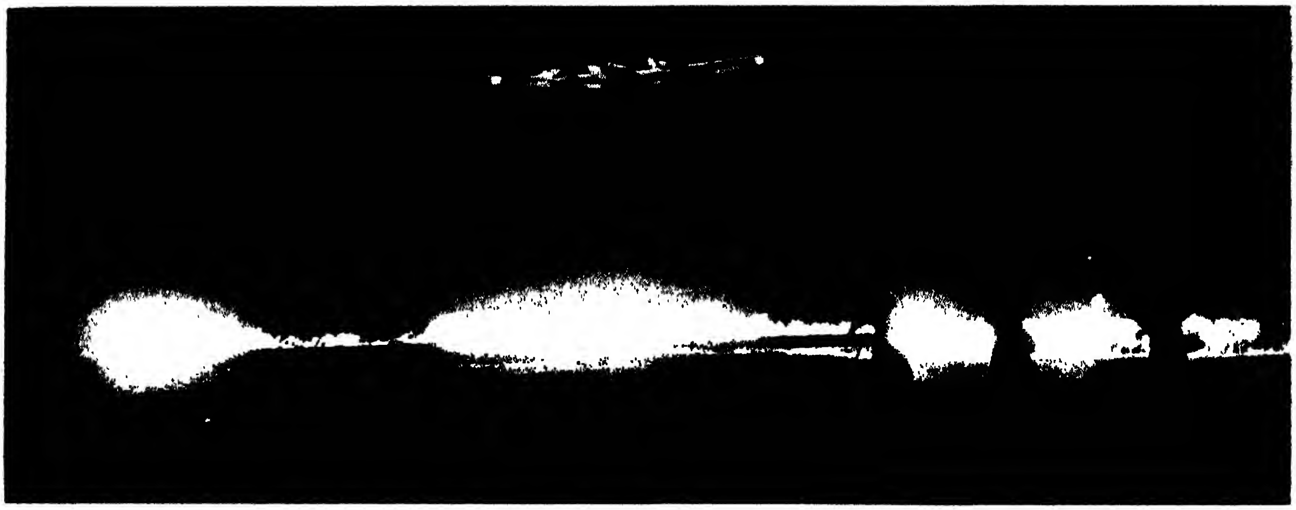
FASTEST LOCOMOTIVE HAULS EXPRESS TRAINS



Drawing based on material supplied by British Railways

in this drawing is only a casing covering the valves through which water is fed into the boiler from the injectors situated under the cab. The height of the engine from the rail level is such that the whistle, instead of standing upright, has had to be placed flat along the fire-box top so that the engine can pass through tunnels. The cab of the engine is large and roomy, with sliding windows at the side and a good look-out to the front. Tip-up seats are provided for the driver and fireman. On long non-stop journeys a relief crew is carried and enters the engine through a corridor in the tender. The various controls in the driver's cab are explained in page 1349.

BURNING FOG FROM AN AIRFIELD'S RUNWAY



This photograph shows you how jets of burning petrol were used at Blackbushe airport in 1952 to clear heavy fog over the runway. The aircraft coming in to land is an Elizabethan twin-engined airliner.

ONE way to clear fog from the ground is to heat the air. This is because heat at ground level warms the layer of cold air above the fog and dissolves the particles of matter constituting fog. In the 1939-45 War, when it was essential that military aircraft should be able to take off and land even when aerodromes were covered with thick fog, the British Air Ministry set up an organisation called Fog, Intensive Dispersal Operation, popularly called F.I.D.O. from its initials, to clear fog by heating the air.

The F.I.D.O. installation consisted of long lines of perforated steel pipes extending for 4,000 feet along either side of the runway and 150 yards apart. Petrol was pumped through the pipes at high pressure and came through the perforations as a spray. When the petrol spraying from the perforations was lit, the runway was lined by a sheet of flame two feet high. This cleared the fog to a height of 100 feet.

F.I.D.O. burnt 1,000 gallons of petrol a minute, and because of its high cost was not easily adaptable to civil aerodromes. In 1952 an improved form of F.I.D.O., and one more economical of petrol, was tried out at Blackbushe airport, near Camberley, Surrey, by British European Airways. The installation took 10 minutes to clear a thick fog so that various types of airliner were able to land safely.

BIG JOINTED ENGINES THAT CAN GO ROUND CURVES

IN order to get greater power, locomotives are being constantly increased in size. In Great Britain the height has reached its limit, and the chimneys have to be of the smallest dimensions or the locomotives would not be able to pass under the arches and through the tunnels.

In increasing the length of a locomotive another problem arises, and that is, that when the engine is of great length, the difficulty and danger of going round curves on the track is also increased. To take a curve safely the locomotive must be short or flexible, and the narrower the gauge the greater is the difficulty.

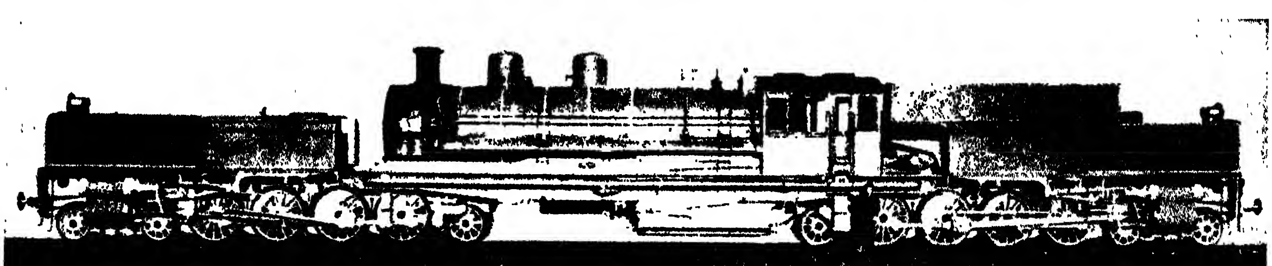
This problem has been solved to a large extent by the design of articulated or jointed locomotives, one of which is shown in the photograph on this page. Engines of this type are known as Garratt locomotives, and, as can be seen, there are two independent chassis which are placed some distance apart and carry between them on a heavy girder frame a boiler of far larger diameter than could be used in a locomotive of the ordinary construction.

A few experimental locomotives of this type have been used in Great Britain, but numbers of them have been built in England for use in foreign countries. They are very powerful and can haul nearly a hundred loaded wagons over heavy gradients.

The Garratt type of locomotive is worked by one driver and fireman, and the locomotive carries its supply of coal and water both in front and at the rear of the boiler.

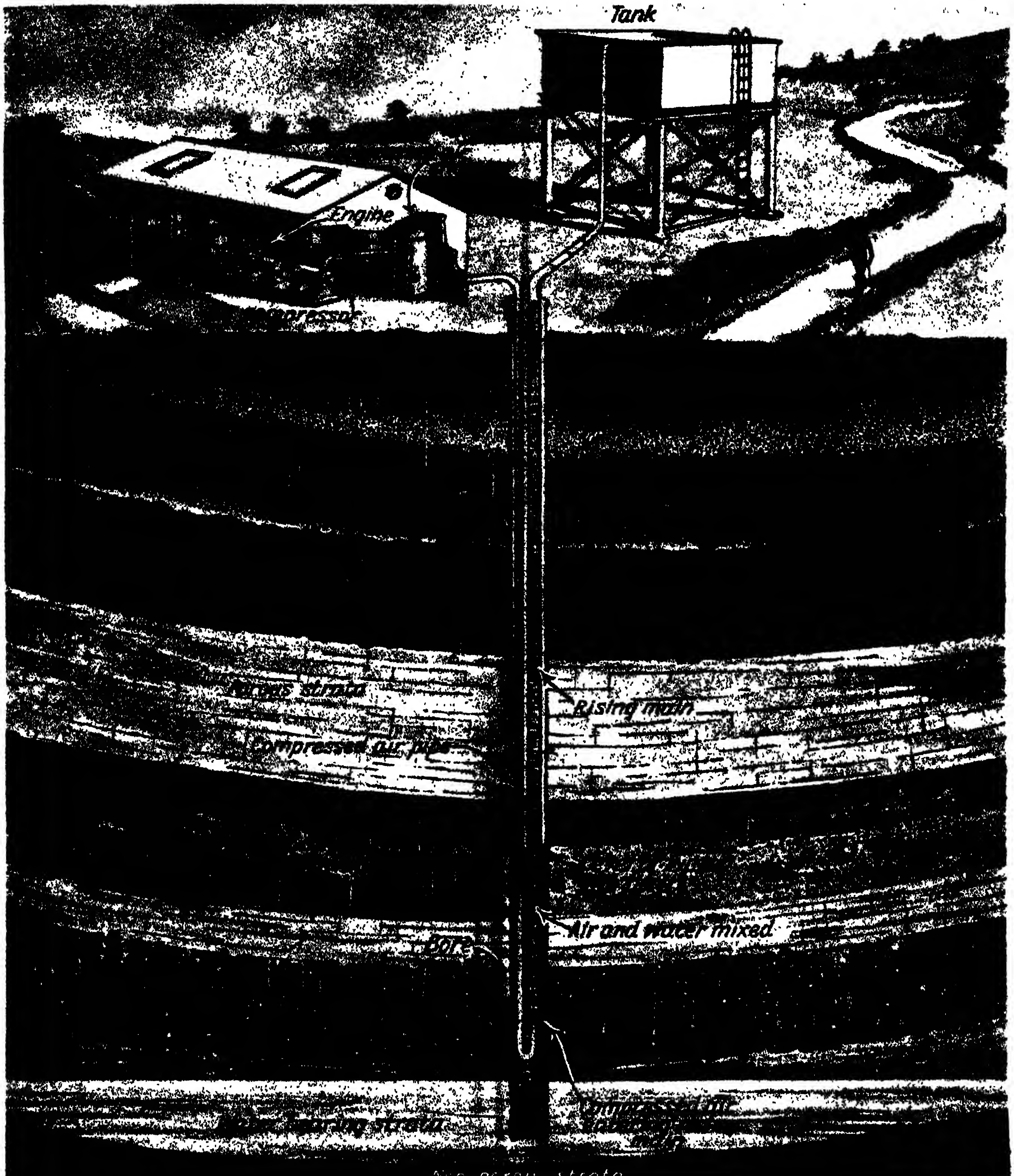
The wheel arrangement of the engine shown in the picture may be described thus: 4-8-2 + 2-8-4. Some of these articulated engines weigh with their chassis over 200 tons. One locomotive of 178 tons used on the Eastern Region of British Railways between Barnsley and Penistone is the heaviest and most powerful locomotive of any kind at work in the British Isles.

Articulated locomotives are used in France, America, South Africa and Russia, among other countries.



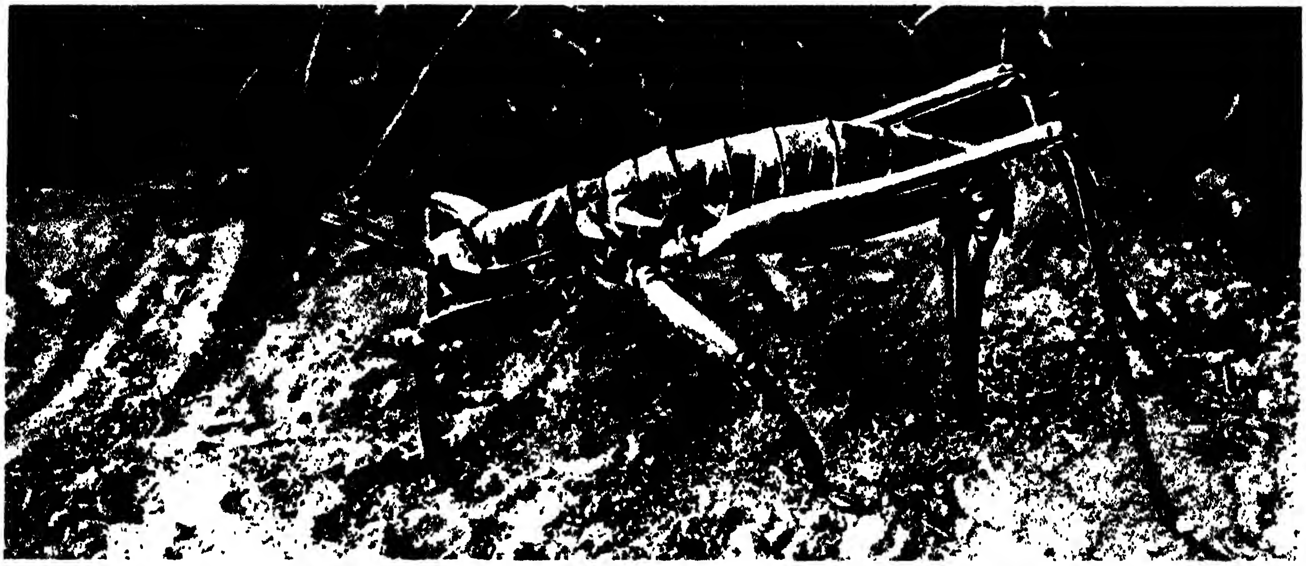
This is the largest locomotive ever built in Great Britain. It was constructed at Gorton for the Russian government and measures 109 feet from end to end. Its weight is 260 tons and it is capable of pulling a train weighing 2,500 tons. This type of engine is known as an articulated or jointed engine, the two chassis with the boiler between them giving flexibility for rounding curves.

GETTING WATER BY COMPRESSED AIR



On this page we see one of the methods of getting water up from a depth by means of compressed air. It is known as an air lift. The pipe or main up which the water comes is sometimes placed inside a slightly larger air-pipe, but sometimes the air-pipe passes down inside the main or water-pipe. A third method is to have separate pipes, one for the water and one for the air, inside the bore. At the surface of the ground there is a compressor, and the compressed air is pumped down so that it can escape into the water main. The whole of the column of water above where the compressed air enters is thereby lashed into foam or into plugs of air and water alternating one above the other. The result is that there is less water in this upper part of the main than there is in the lower part, and the mixture of air and water being lighter the pressure of water in the earth all round the bore causes the liquid to rise, driving up the aerated water. A well of this type needs the bore hole to be deeper than for ordinary pumping, but the supply of water obtained is much greater. The air-lift has many advantages over ordinary pumping. It can, for instance, be worked from a convenient point at a considerable distance from the well; and there are no moving parts down in the bore hole to get out of order

THE LOCUST AND ITS INVADING ARMIES



The locust right through history has been one of the greatest enemies of mankind. There are many references to its depredations in the Bible, and an invasion of locusts was one of the great plagues of Egypt. Locusts are found in both the Old World and the New. Here is a locust in the Argentine photographed while laying her eggs. She places her ovipositor in the ground and lays about forty eggs in a mass. Locusts are sometimes five inches in length, and they are very powerful insects for their size. They have strong hind legs and can leap over great distances. They also have tremendous powers of flight, and can travel far without alighting. The young locusts when hatched resemble their parents except that in the early part of their life they have no wings

A swarm of locusts will darken the sky for hours at a time as they pass, and the noise of their wings as they travel is remarkably loud, and has been likened by old writers to the rushing of a broad river. When they alight and eat their constantly moving jaws make a noise like " chariots in battle." On the left we see a flight of locusts photographed on a bright sunny morning near Jerusalem in Palestine, and on the right are some of the same locusts settling on cactus plants. These armies of locusts when they invade a country are almost incredible in size. One which passed over Morocco in 1932 was nine miles long and four miles wide. It must have contained hundreds of millions of insects, and a short time afterwards another locust army passed measuring ten square miles

THE BIGGEST ARMIES IN THE WORLD

Of all the insect pests that war on mankind probably the locust does most damage. It is found almost all over the world, and its numbers are incredible. It alights by the million on a wide stretch of country and an hour or two afterwards not a vestige of green is to be seen. The locusts have devoured it all. In these pages we learn something about the devastating power of these remarkable insects

THE locust has always been the bugbear of the countries in which it is found, and in which it does its fell work. No more dramatic description of what the visit of an army of locusts means could be found than that given by the prophet Joel in the Old Testament: "The land is as the Garden of Eden before them, and behind them a desolate wilderness; yea, and nothing shall escape them. The appearance of them is as the appearance of horses and as horsemen so shall they run. Like the noise of chariots on the tops of mountains shall they leap, like the noise of a flame of fire that devoureth the stubble; as a strong people set in battle array. They shall run like mighty men, they shall climb the wall like men of war, and they shall march every one on his ways, and they shall not break their ranks."

No wonder the writer likens a visit of locusts to a terrible judgment, "a day of darkness and of gloominess, a day of clouds and of thick darkness."

The female locust lays its eggs in groups in holes drilled in the ground. The young locusts that hatch out begin destroying the vegetation at once, and they go on doing so right through their lives. They moult several times and then reach the winged stage when they fly in swarms sometimes for hundreds of miles. But even in the wingless state they travel over wide areas.

Locust swarms have been seen at sea 1,200 miles from land. The size of some of the swarms is amazing. One that flew across the Red Sea in 1889 is said to have covered an area of 2,000 square miles.

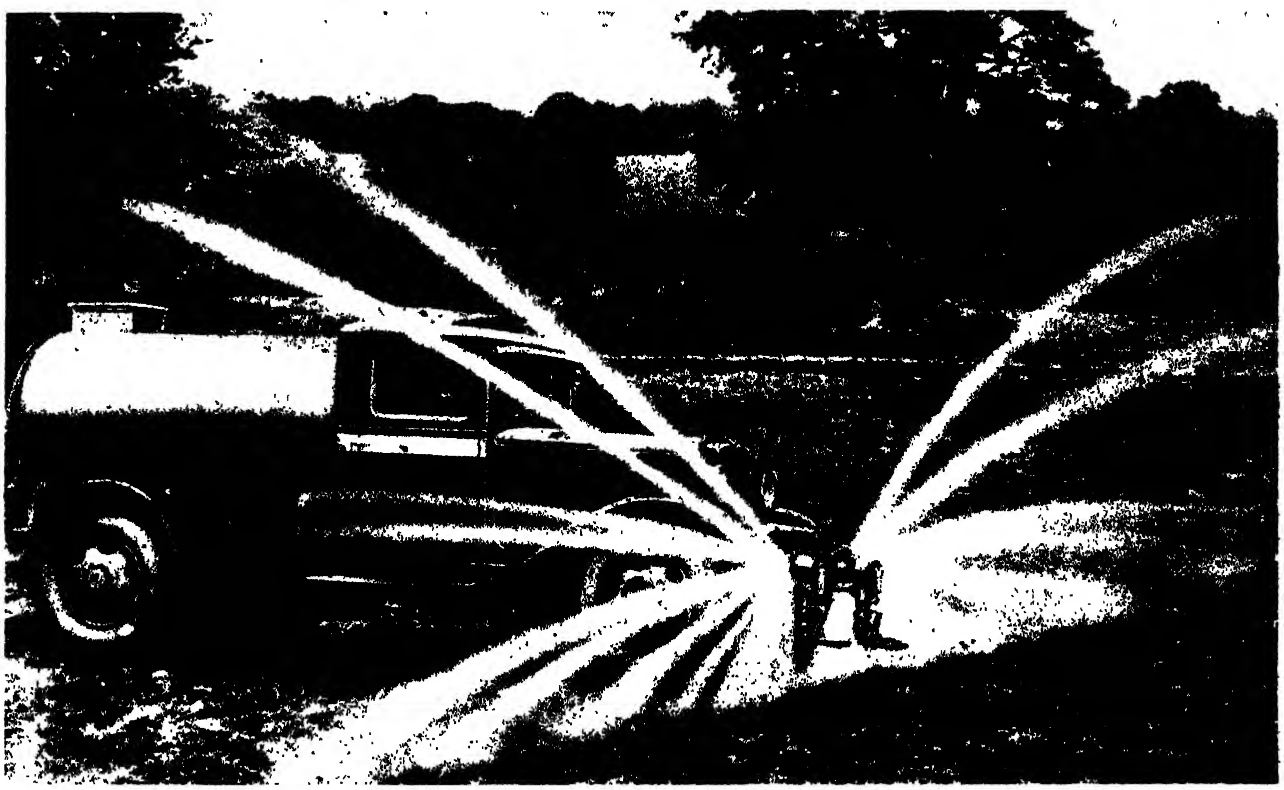
In one year alone in the island of Cyprus over 200,000 million locusts were destroyed, at a cost of 2s. a million, together with over 1,3 0 tons of eggs.

Great advances in fighting the locust have been made in recent years by scientific methods of spraying, and before the winged state is reached the locusts are caught by millions in trenches dug across their routes of march. Parasites which prey upon them are also being used, and a microbe disease has also been successful in reducing their numbers.

This photograph shows the head of a locust magnified, and as can be seen it has a remarkable likeness to a horse's head. In fact, this type of locust, which does immense damage in the Argentine, is known as the horse-headed locust. Similar locusts are found in Africa, and it is an interesting fact that in the New Testament in the 9th Chapter of Revelation, the writer, in speaking of locusts, says "The shapes of the locusts were like unto horses prepared unto battle." He must have studied locusts of this type. An International Locust Research Committee now gathers information from all nations to assist in fighting the foe

MODERN METHODS OF WAR ON THE LOCUST

Only those who have lived in a locust-ridden country can have any idea of the devastation wrought by a swarm of locusts when the insects alight. Everything green disappears in an incredibly short space of time, for the locust has powerful and quickly moving jaws. In these photographs, which were taken in Israel, we see on the left a fig tree before the locusts arrived, and on the right the same tree picked clean of every vestige of leaf and fruit after their departure. Israel has always been a great sufferer from locusts.

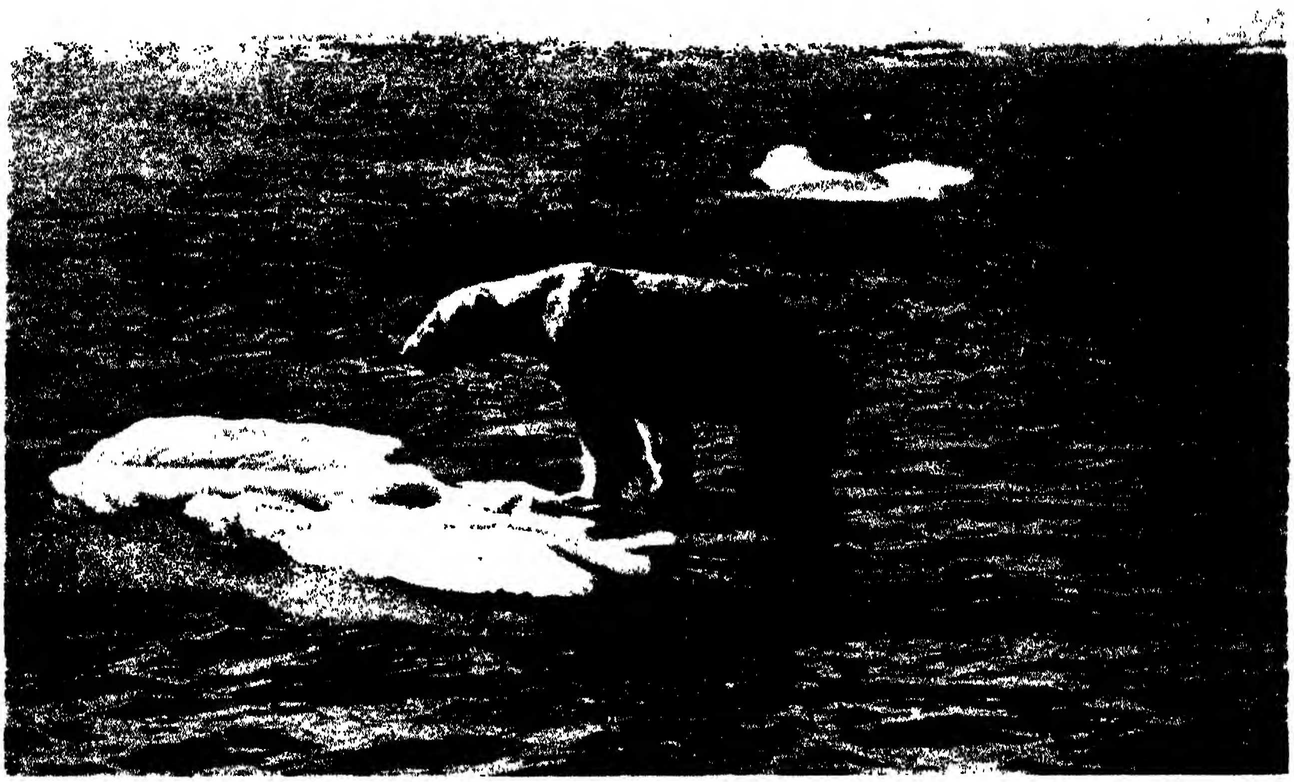


For thousands of years man has waged relentless war against the locust, but the result has generally been "a draw." Nowadays, however, with international co-operation and scientific knowledge, better results are being obtained. Here, for example, we see one of a number of vehicles built in England for use in Iraq, where the locust destroys great areas of pasture. They are filled with a poisonous liquid chemical known as sodium arsenite, and are then driven over the country where the wingless forms of locust are found, spraying the poison, which destroys the insects. Each tank holds 400 gallons of the spraying fluid, and this is one of the most effective methods of fighting the locusts. Helicopters are used in America for spraying, and so killing, some kinds of insect pest.

OLIVE SEAWEEDS OF THE BRITISH SEAS

The seaweeds of the British coasts may be divided according to colour into three classes—red, green and olive. We see some familiar red seaweeds on page 615, and here are a number of olive seaweeds. Their names are as follow: 1. Myriotrichia filiformis; 2. Fucus vesiculosus; 3. Punctaria plantaginea; 4. Himanthalia lorea; 5. Ectocarpus granulosus; 6. Halidrys siliquosa; 7. Laminaria saccharina; 8. Dictyosiphon foeniculaceus; 9. Dictyota dichotoma; 10. Laminaria phyllitis; 11. Asperococcus Turneri; 12. Chorda filum; 13. Asperococcus echinatus; 14. Striaria attenuata; 15. Ectocarpus siliculosus; 16. Chorda lomentaria; 17. Chordaria flagelliformis; 18. Ectocarpus littoralis

A POLAR BEAR MAKES A LONG JOURNEY



Polar bears are good swimmers and can travel long distances in the water, but they sometimes go much farther than they could swim. This they do by travelling on floating masses of ice, and they sometimes reach Iceland in this way. Then there is a great hunt to destroy the Polar bear before it can do any damage. These bears that drift across to Iceland in the manner shown in this photograph come from the coast of Greenland. Explorers in the Arctic often see Polar bears on icebergs far out at sea. These animals live by diving off their ice-raft to catch fish or seals and can satisfy their thirst by licking the ice

THE WAY IN WHICH A FISH MOVES THROUGH WATER

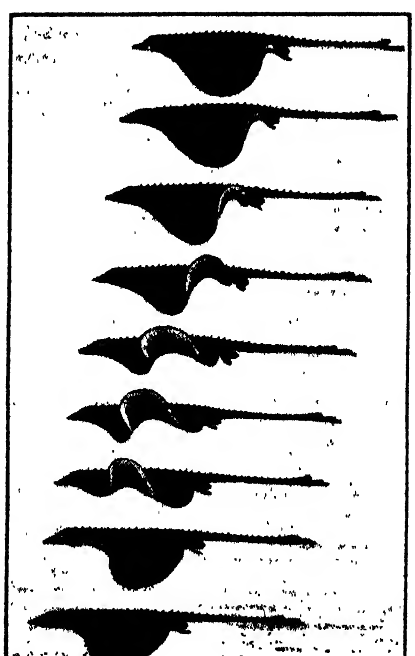
It is always interesting to know how creatures move. We watch the birds in the garden, for example, and see that some hop while others walk or run, and they all fly.

The movements of the worm, too, are interesting. It has on its body a number of bristles or prickles which are sometimes called "feet," and these are its organs of locomotion. By means of them the worm is able to pull itself along

Then we have seen how some of the bivalve shellfish, like the scallop on page 992, propel themselves by opening and closing the valves of their shells

When we come to the fish we find that the tail is in many cases the great organ of locomotion. Since the establishment of the Aquarium at the London Zoo and one or two other excellent aquariums, we are able to watch the movements of these creatures through the glass sides of the tanks in which they are kept.

There are two movements of the tail going on at the same time, both of which are used in propelling the fish. The tail is moved from side to side and this drives the fish forward in the same way as a paddle worked to and fro in the back of a boat But at each stroke the tail partly rotates about its long axis, so that it has somewhat the motion of a screw propeller The fish is thus driven forward partly by a rowing motion and partly by a screw motion. In some of the fishes with very stout bodies the screwing movement does most of the work of locomotion.



Successive movements of the body of a ray as it swims through the sea

In many cases the fish have also fins with which they balance and steer. This is the use of the fins on the sides of the body and on the back.

The movements which have been described apply to the torpedo-shaped fishes, like the herring, cod and so on. In the flat fishes like the rays and skates and soles, the water is struck by the surface of a great part of the body. The picture on this page shows the various motions of the ray when swimming Its tail is kept out straight behind and with the immense fore-fins that border its body it strikes the water and drives itself forward. The sides of the body are pressed down and then raised from the back to the front, in the manner shown, which gives the progress.

In the case of the so-called flying fishes their movement out of the water is a very specialised one. Of course it is not flying in the sense that a bird flies; it is really a form of gliding, helped by the very large breast fins which support the fish in the air.

The jellyfish propels itself by the opening and contraction of its umbrella-like body, and the octopuses and cuttlefishes move by shooting water from a kind of siphon as they contract their mantle. The movement is assisted by the webbed arms which as they open and close have the same effect as the jellyfish's "umbrella."

HELPING NATURE TO IMPROVE HER WORK

NATURE performs almost incredible wonders in the world of plants. Clear a space in the centre of any large town by demolishing the houses and leave the vacant brick-strewed area unattended, and in a month or two the whole place will be a mass of green vegetation, with patches of colour here and there produced by various blossoms.

Some years ago, when the ground in London on which Kingsway now stands was cleared, more than a hundred different plants were found growing on the site twelve months later. The seeds that produced the plants had been blown there by the wind from market carts going to Covent Garden, or dropped by birds flying overhead. The soil would hardly have seemed fertile enough for this, and yet in an even less favourable soil Nature performs her wonders.

When an examination was made some time ago of the walls of the Colosseum in Rome, 420 different kinds of plants were found growing on them, the roots finding their way into the crevices of the masonry and absorbing sufficient nourishment to give them life and health.

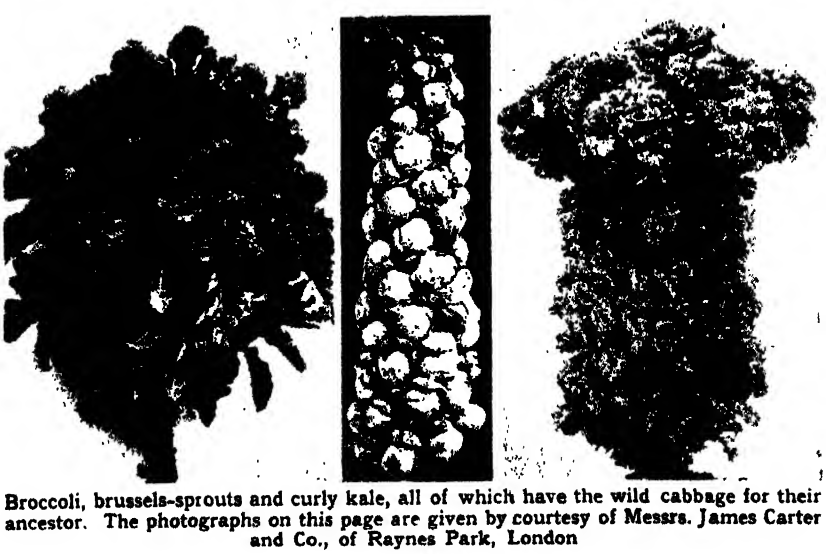
Almost the whole earth is covered with vegetation of some kind. Only the dry sandy deserts of Africa and Asia, and the snow-clad mountain-tops are bare of plants. It is a good thing that this is so, for man and beast depend upon the plant world for their sustenance. Even those animals which are carnivorous would get no food did not the beasts on which they prey find their nourishment in plants.

But though Nature is so prolific, many of the food plants on which man is dependent would have been worth very little if Nature had been left to herself. It is by the help of man that she is persuaded and enabled to do better and better.

Her unaided efforts gave us the sour crab-apple and the small, hard, harsh wild pear. From these man has persuaded the earth to yield the large and luscious apples and pears, sweet and juicy, which can now be bought in any fruit shop in a town far removed from where the trees grow. These fruits have been improved out of all recognition in flavour, size and colour.

The wild cabbage, the ancestor of all the vegetables below

A fine large cabbage and a splendid cauliflower produced after long plant breeding from the wild cabbage plant shown above



Broccoli, brussels-sprouts and curly kale, all of which have the wild cabbage for their ancestor. The photographs on this page are given by courtesy of Messrs. James Carter and Co., of Raynes Park, London

Other wild fruits, the unassisted efforts of Nature, like the wild strawberry, are dainty in flavour, but they are very small and few fruits are produced on each individual plant. Man has helped Nature so that we now get the large and delicious strawberries which are gathered by the million every summer.

The improvements which man achieves in the plant world lie in several directions. He increases the yield so that one plant will give far more seeds or fruits. Then he increases the size and quality of the individual fruits. He also multiplies the varieties of the fruits and increases their desirable qualities, such as sweetness, juiciness, flavour, and so on. Finally, he enables plants that would once grow only in one kind of climate or soil and ripen only at one period of the year, to grow anywhere and almost at any time.

In doing this man works in two ways. One is by selecting what Nature herself produces, and the other way is by combining different plants so as to produce the best qualities of all.

From very early times man has known the value of watching the plants and selecting the seed from the best so that his next crop should be better than his last. The great Roman poet Virgil says:

> I've seen the largest seeds, tho' viewed with care,
> Degenerate, unless th'industrious hand
> Did early cull the largest,

and another writer, Celsus, a hundred years later, declared that "Where the corn and crop are but small, we must pick out the best ears of corn, and of them lay up our seed separately by itself."

We read in another part of this book how man has produced the wonderful wheat crops that are grown to-day from a wild grass that yielded very little in the way of nourishment, and he has done the same thing in the case of thousands of other plants. Fruits and flowers are far more varied and magnificent to-day than they were even fifty years ago, and the assistance man has

given to Nature in plant-breeding, as it is called, has so enormously increased the yield that what a few years ago were luxuries for the rich are now within reach of all.

Half a century ago only the well-to-do could afford to buy such things as tomatoes and bananas. We all have them regularly now. Oranges, within reach of all, are to-day nearly twice as large and twice as sweet as those that were available for the mass of people in the days of our grandparents.

The same thing is true of flowers. At the beginning of the nineteenth century there were only 46 different kinds of roses. Now there are many thousands, and fresh kinds are constantly being produced.

Luther Burbank, the Plant Wizard of America, of whose wonderful achievements we read in other parts of this book, once said : " Search this Earth all over, climb every mountain, plunge into every canyon, valley and jungle ; and when all this is done visit every park, garden, nursery and conservatory; go anywhere, everywhere, and as many varieties of charming lilies cannot be found as I have produced. All the Earth is not adorned with so many new ones as are growing at my establishment."

It was true. Burbank grew at his plantations in California over a million lily bulbs, and produced no fewer than 250,000 distinct lily hybrids all yielding flowers different in form or colour.

A Slow Process

Up to the middle of the eighteenth century the only way of improving plants or making new varieties was by selection. One or two were chosen which chanced to be exceptional, and new plants were grown from these in the ordinary way. But this natural process is a very slow one, although wonders can be performed by selection alone.

Burbank one day noticed a wild yellow poppy growing on a Californian hillside which had a thin crimson line on one of its petals. He transferred the plant to a nursery bed in his grounds, and at the end of the season saved its seeds. He sowed them in a special bed, and when the plants grew and flowered he found that some of the blossoms had a slightly wider crimson band. Again he selected, destroying those he did not want, and at last he produced a race of entirely crimson poppies.

Another plant-breeder, the Dutch botanist de Vries, one day found a clover plant with several leaves divided into four instead of three. He took seed from this plant and grew others, and found that there were several clover plants whose leaves were divided into four, five, six and even seven. By continually selecting he at last produced a clover almost the whole of whose leaves were divided into four, five, six and seven, instead of into three like the ordinary clover plant.

The wild strawberry plant of the woods and thickets with its small fruits

The splendid strawberries that are now produced from cultivated plants developed by man from the wild plant shown above

Nowadays men of science do not wait for Nature to show some improvement. As already explained, they combine the desirable qualities of different plants in one plant, and this is what is known as crossing or hybridising. They take the pollen from the stamen or male part of one plant and transfer it to the pistil or female part of another plant. The female plant is thus fertilised and produces seed, which when planted gives a hybrid plant combining the qualities of both. And so the work goes on, and it is almost true to say that man can to-day produce any kind of a flower or fruit that he wants.

A camel-hair brush is often used for transferring the pollen from one plant to another. The seeds from the new plant are put into the soil and the seedlings produced by them are carefully examined. Those which do not show the desired characteristics are destroyed, while from those which do, further selection is made. Thus by repeated selection and cross pollination whatever type of fruit or flower is desired can be produced.

The work of the Austrian abbot Mendel, of which we read on pages 509 to 511, has enormously simplified the work of plant-breeders by letting them know surely what the offspring of two different types of plant will be like.

Of no plant is it easier to grow new varieties, chiefly by selection, than the bean which is known by such names as haricot, butter bean, and so on. The production of new kinds of beans suited to special purposes has been brought to such scientific perfection that seedsmen now even advertise a new kind of bean before the variety has been actually produced. They order what they want from their plant-breeder, and invariably get it within two or three years, ready for their customers.

Changing the Maize

Indian corn, or maize, is a very useful plant which grew originally in tropical and sub-tropical lands, and needed a long growing season. Now there are varieties ranging from those which grow eighteen feet high and require six months to mature, to those which are only two or three feet high and whose growing period is 90 days or less.

Another remarkable result of plant breeding is found in the great variety of excellent vegetables that have been developed from the small and unattractive wild cabbage of the sea cliffs. From it by careful selection have been obtained not only the large garden cabbage but the cauliflower, the broccoli, brussels-sprouts, the curly kale and the kohl-rabi, with its turnip-shaped stem, used as food for cattle.

No one can say what amazing results may yet be achieved by the plant-breeders.

WONDERS OF THE SKY

A PLANET FOUND BY MATHEMATICS

The existence of the planet Neptune was known before it was ever seen through the telescope. Its position was worked out by mathematics, as we read here, and this was a great triumph for science. Its discoverer was really a young English student of Cambridge University, although the first man to see the planet was a German astronomer. A French scientist working independently had also calculated the unknown planet's position in the heavens

When in 1781 Sir William Herschell, sweeping the heavens with his seven-inch reflector telescope to see what interesting objects he could find there, saw Uranus and recognised it as a planet, he had made the first discovery of a new world in historic times. All the other planets from Venus to Saturn had been known to the Ancients, but here was a new world to add to the list of planets in the Solar System.

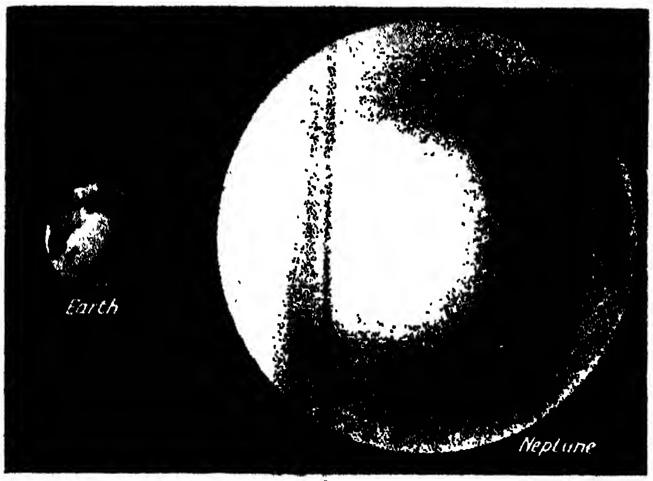
The orbit was soon worked out and studied, but by 1820 it was discovered that the new planet did not seem to be following exactly the path that was computed for it. Why was this? It is true the deviation was very small, but astronomers and men of science generally make great discoveries by taking notice of small things.

In 1830 a German astronomer, Frederick Bessel, suggested that the discrepancy between the calculated and actual orbits of Uranus must be due to the attraction of an unknown planet farther away than Uranus itself. This idea set other scientists working and in 1843 a young student of St. John's College, Cambridge, named John Couch Adams calculated how far away the unknown planet must be and what its orbit was like. He checked his figures, and in 1845 sent them to Sir George Airy, the Astronomer Royal, who, however, showed no very lively interest and allowed the proposed search for the planet with a telescope to be postponed.

Meanwhile, a young French astronomer, Urbain Leverrier, made similar calculations quite independent of Adams, and a few days after Adams had sent his suggestions to Sir George Airy, Leverrier communicated his findings to the French Academy and a little later sent his results to a German astronomer, John Galle.

He suggested that Galle should turn his telescope towards a certain part of the heavens and there search for the missing planet. This Galle did and on September 23rd, 1846, the first evening that he looked, saw the distant world, which was named Neptune.

Adams and Leverrier must share the honour of the discovery of Neptune, though it is beyond doubt that Adams had worked out his calculations some time before the Frenchman. It is curious that though their calculations enabled the planet to be found in the sky, many of their figures, as, for instance, the size of the orbit, and so on, were afterwards found to be incorrect.



The Earth and the planet Neptune drawn to the same scale. It will be seen that Neptune is a large world, but no distinct markings can be detected on its surface

In this picture-diagram we see the distance of the Earth from the Sun and the distance of Neptune drawn to the same scale, but, of course, no attempt is made here to represent the Sun and the planets in their relative sizes. This is done for the Earth and Neptune in the upper picture. Neptune has a moon, Triton, circling round him at a distance of 221,500 miles

What sort of a world is Neptune that was found in so curious a manner by men of different nationalities. Well, it is a great sphere with a diameter of 32,900 miles, that revolves round the Sun at a mean distance of rather more than 2,800 million miles The orbit is almost a circle and Neptune travels round it at a speed of just over three miles a second, or 268,000 miles a day, so that its year is equal to about 165 of our years.

Neptune is quite invisible to the naked eye, but it can be seen as a point of light by means of good opera or field glasses. Through a telescope it appears as a small star between the eighth and ninth magnitudes with a greenish disc.

Its volume is 85 times that of the Earth and its mass or weight 17 times. This means that the density of its matter is rather more than a fifth of that of the Earth.

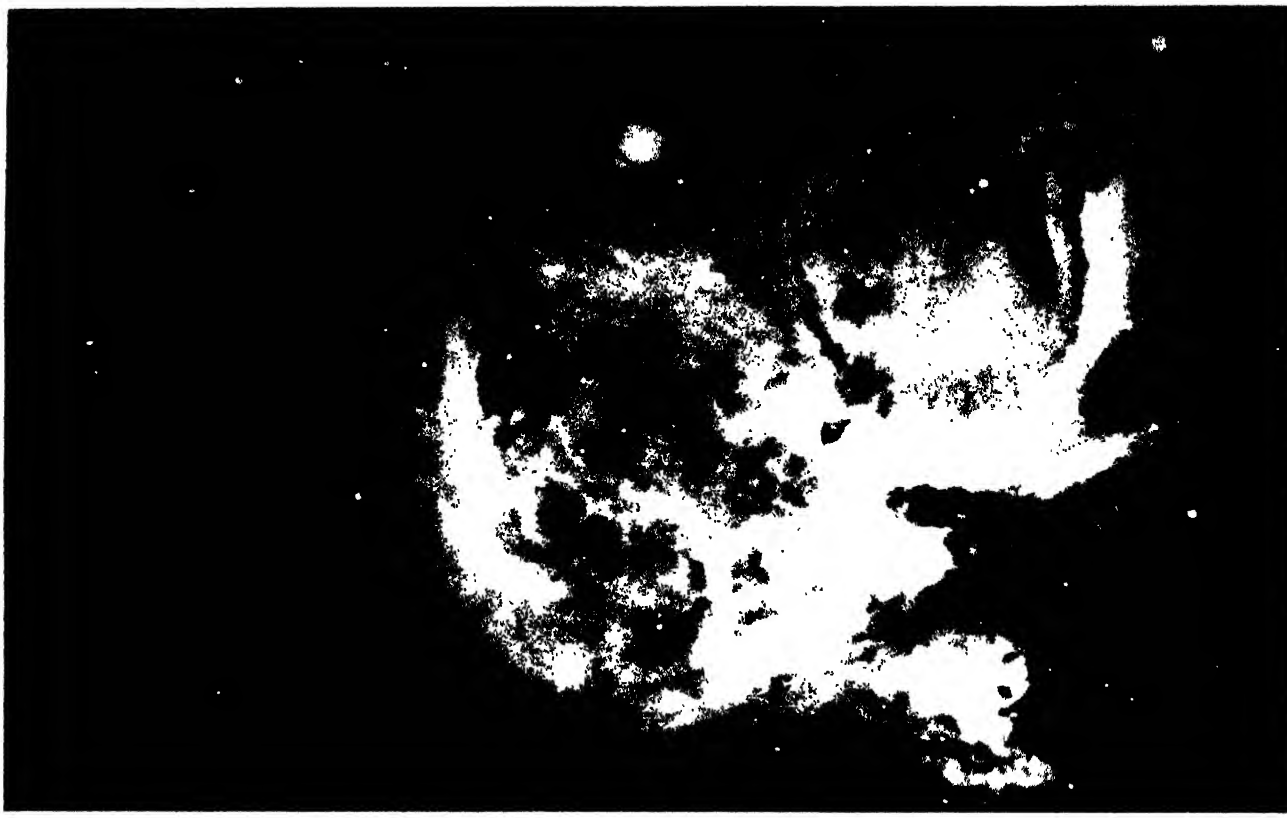
As there are no markings of any kind visible on Neptune's disc, it might seem that nothing could be known about its rotation, for it is by watching the markings on such planets as Mars, Jupiter and Saturn that we can calculate the time they take to turn round on their axes.

But astronomers do some very clever things, and by studying the amount of bulge at Neptune's equator they have worked out the speed of rotation necessary to give this bulge. They have also calculated the speed of rotation by means of the spectroscope, and from these figures they believe that the planet turns round on its axis in about 15 hours 8 minutes.

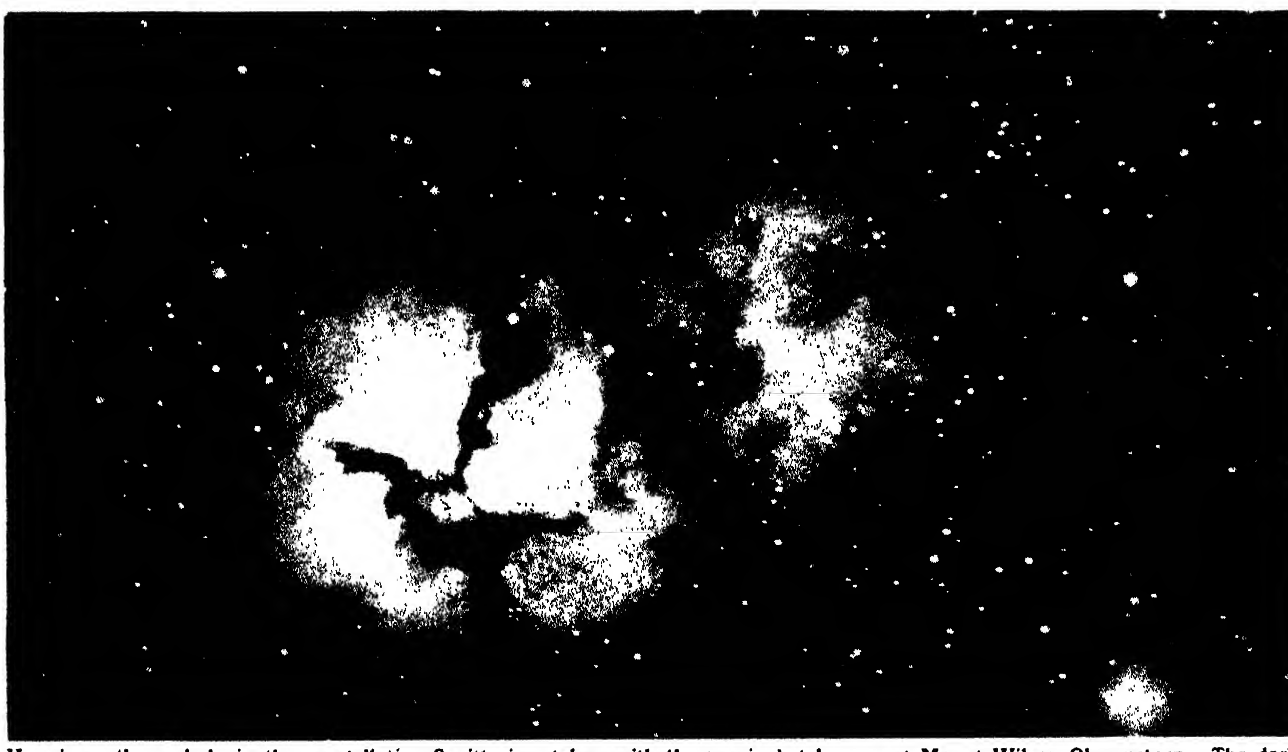
Neptune is so far from the Sun that it receives only one-900th of the heat and light that comes to our Earth from the same source. At the same time the sunlight received by Neptune is much stronger than the starlight it receives, being equal to a light of nearly 700 full Moons. As seen from Neptune the Sun would look as bright as a 1,200 candle-power electric arc light at a distance of 12 or 13 feet.

Neptune has one satellite or moon, discovered by William Lassell.

VAST CLOUDS OF GLOWING GAS AND DUST



Here is a photograph of the Great Nebula in Orion taken with the 100-inch telescope at Mount Wilson Observatory in California. The central portion has been reduced in intensity in order to bring out the detail of other parts. It is interesting to compare this photograph of the nebula with that on page 198, where there has been no reduction of the central light. The huge quantity of dust mixed with the luminous gas and in some parts lighted up by it, but in others left dark, is known as cosmic dust



Here is another nebula, in the constellation Sagittarius, taken with the 100-inch telescope at Mount Wilson Observatory. The dark patches are particularly noticeable, and they are supposed by astronomers to lie between us and the glowing gas of the nebula, and to consist of vast quantities of cosmic dust, which shuts off or absorbs the light that comes to us from the nebula. These clouds of gas are millions of millions of miles in extent and yet they have very much the appearance of the small clouds on the Earth

HOW MAN SOARS IN THE AIR LIKE A BIRD

Gliding has been rightly called the yachting of the air; for like the yachtsman the glider pilot must know how to use the wind to take him from place to place. But gliding is something more than a sport; experiments with gliders have led to many improvements in the design of aeroplanes, while the flying of gliders is good training for the piloting of engined aircraft.

Gliders are the only flying machines that are able to soar like birds, and inventors had been trying to build them long before the first powered aircraft flew. One of the greatest experimenters with gliders was Otto Lilienthal, a German, who spent several years in the scientific study and measurement of bird flight. His discovery that there were upward currents of air which helped birds to fly laid the foundation of the art of gliding by human beings.

Lilienthal made countless gliding flights and was able to glide for distances of nearly a quarter of a mile at heights up to 100 feet. After Lilienthal's death in a gliding accident in 1896, other experimenters carried on his work and eventually developed the reliable gliders used to-day.

In its construction and method of control, the glider is simply an aeroplane without an engine, but its piloting is a matter of great skill. There are three types of gliders: primary, secondary, and sailplane. A primary glider is an open-framework machine used for training; a secondary glider has finer lines and gives the pilot more power of manœuvre; while the sailplane is for the expert pilot and can be flown for long distances at great heights.

There are several ways of launching a glider into the air. It can be released from the ground by catapult; towed off the ground by human power like a kite; towed off the ground by a car travelling at high speed; towed into the air by an aeroplane; or sent off by the discharge of rockets attached to the rear of the fuselage.

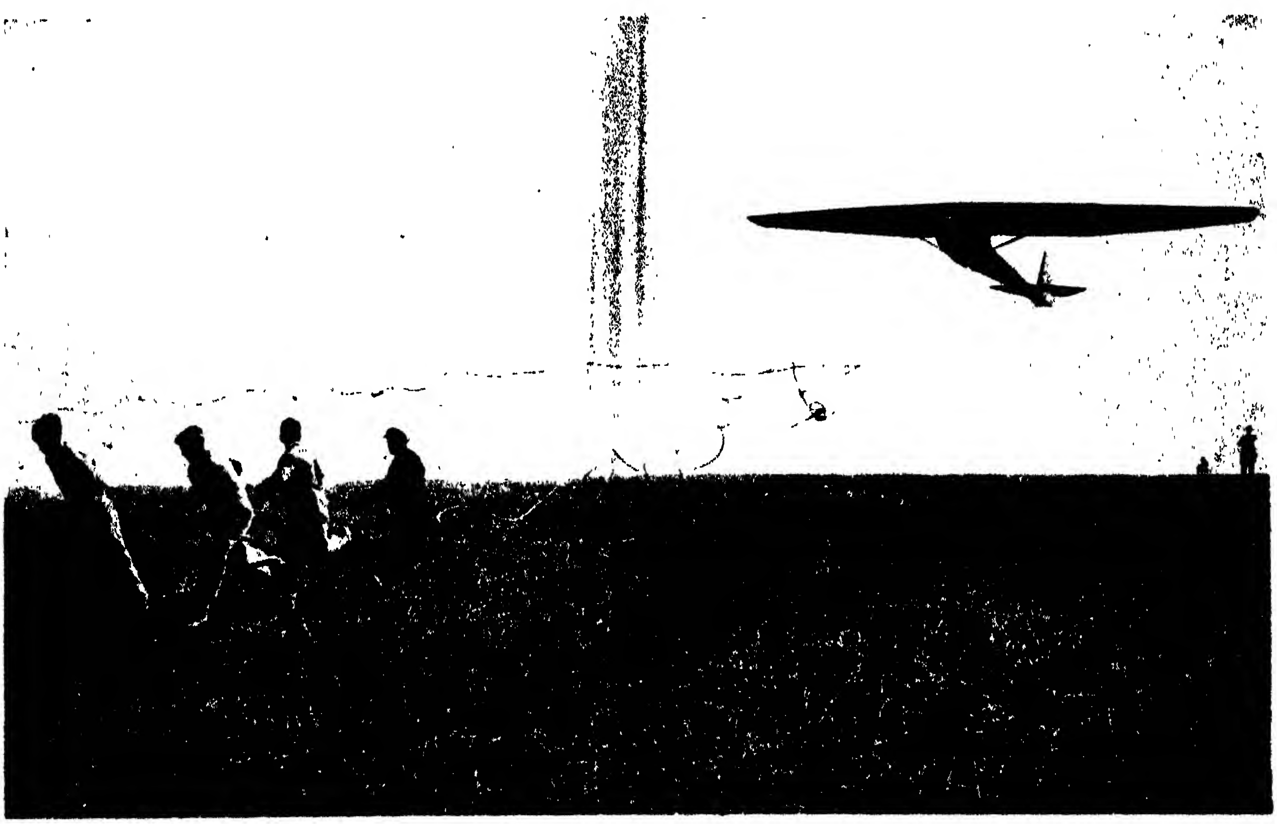
When the glider becomes airborne, the pilot keeps his machine in flight by taking advantage of every available source of upward movement of the air, which, by pressing against the under surfaces of the glider's wings, forces the machine up. When enough height has been reached, long distances can be flown by slightly forcing down the nose so that the aircraft starts to glide. The momentum of the glide will then carry the glider up again when the pilot pulls the joystick and so raises the elevators on the tail.

Upward currents of air are essential if the glider is to reach a good height. These upward currents are caused by the deflection of the wind blowing against and over hills, trees and other large objects.

Another important source of "lift" for gliders is provided by the sun, particularly in summer. By heating the surface of the ground, the air above it is warmed and caused to expand. The expanding air will then force upwards any glider passing over it. As air is always rising towards clouds, long glider flights can be made by flying under clouds, or "hopping" from cloud to cloud.

Long-distance glider flights are also made by flying with the wind, just as a sailing boat makes its best speed with the wind behind it. Experienced glider pilots are even able to fly against the wind by adapting to their art the principle of tacking used by yachtsmen. In this way glider flights of 150 miles are quite common.

During the 1939–45 War, gliders were used to land troops and supplies in enemy held territory. The gliders were towed singly or in strings of three behind an aeroplane which released them over the area to be attacked. The gliders were then landed on the objective by their own pilots. Military gliders were able to carry loads weighing up to three tons.

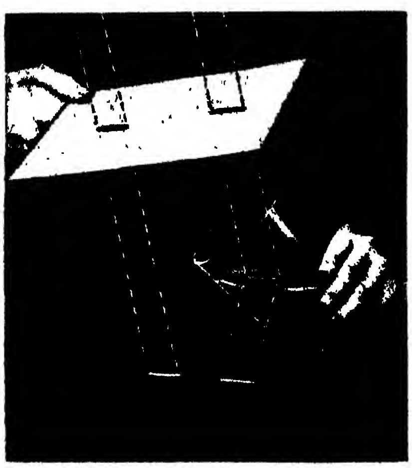


In this photograph a glider has just become airborne after being pulled off the ground by men hauling on a rope. The action is much the same as that used in launching a kite. When the glider is airborne, the pilot releases the rope by means of a lever in the cockpit. In the photograph the rope can be seen falling away.

A GROUP OF SIMPLE OPTICAL EXPERIMENTS

The tiger that enters the cage when looked at as shown here

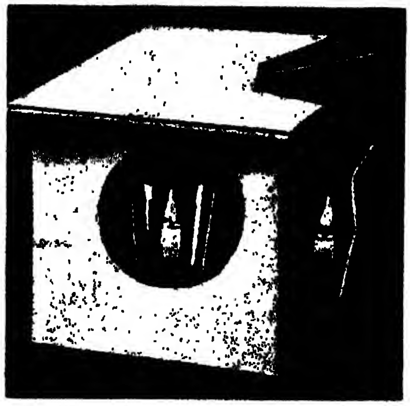
HERE are some interesting experiments that help us to understand things about light and seeing. Draw on a post card a cage and about half an inch away a tiger. Then, holding the card in one hand, take another post card in the other hand and hold this at right angles between the cage and the tiger. Bring the face close to the card, so that the left eye sees the cage only and the other eye the tiger only. After looking for a few seconds the tiger will seem to move forward and enter the cage. This is due to the separate impressions received by the two eyes being combined by the seeing part of the brain



A simple experiment to prove that light rays are bent when they are passing from air to water

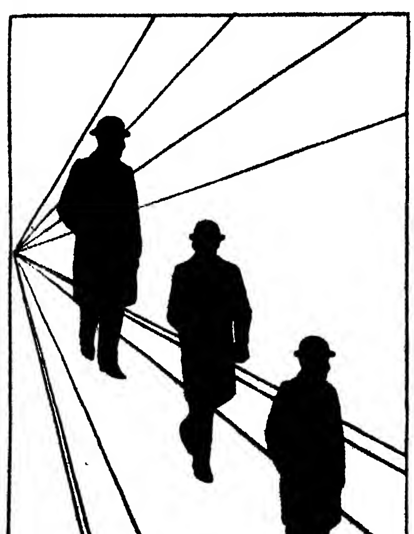
Another interesting experiment with a cage can be performed in this way. Take a small card about two inches deep and three inches wide, and on one side draw a bird-cage, and on the other side, but the reverse way, that is, upside down, a bird. Now fasten a piece of thin twine to each side of the card and begin twisting the threads backwards and forwards, so that the card rotates to and fro rapidly. The bird will appear inside the cage. This is owing to the persistence of vision, the images of the cage and the bird remaining on the retina so that one combines with the other.

Here is another experiment which shows clearly that light is bent when it passes from one medium into another, as from air into water or from water into air. Take a card and cut two slits in it. Let the Sun's rays pass through these slits and shine upon a dark tablecloth. We shall see two bars of light. Now, keeping the card in position, hold a glass of water under one of the slits. At once the position of the bar of light on the cloth will change, because the ray of light has been bent by the water

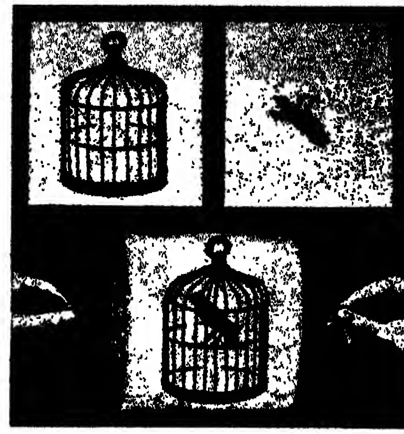


An amusing Pepper's ghost toy

We can obtain a good optical illusion of the Pepper's ghost type in the following way. Take a wooden box and make a round opening in one side. Place a glass of water in what, in the picture, is the farthest corner, and fix diagonally across the box a sheet of plain glass. On the near side of this stand a small piece of candle. Light it, and if the top of the box is open cover it with a piece of wood. Now look through the opening, and the candle will seem to be burning inside the



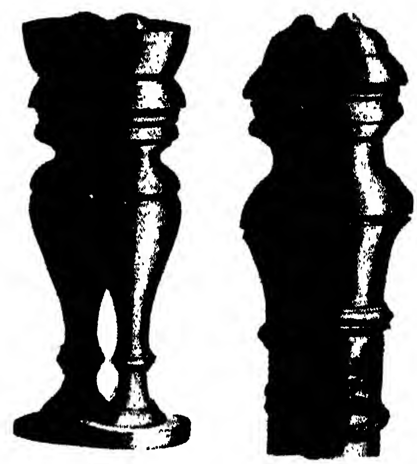
Which is the tallest of these three figures? When you have guessed measure them



How to make the bird on one side enter the cage on the other

tumbler of water. The tumbler is seen through the glass at the same place that the candle is reflected upon the glass. Before showing the experiment to anyone else we must be sure to get the candle and glass in the right positions.

In the bottom picture on this page we have an optical illusion. Let us see which of the three figures we think is the tallest, and then measure. We may be surprised to find that all three are the same height. The lines drawn in perspective give us a wrong impression. The third figure appears far away from the first, and we naturally think it must be very much bigger.



Shadows of Napoleon and Louis XVI cast by carved wooden blocks that disguise their object

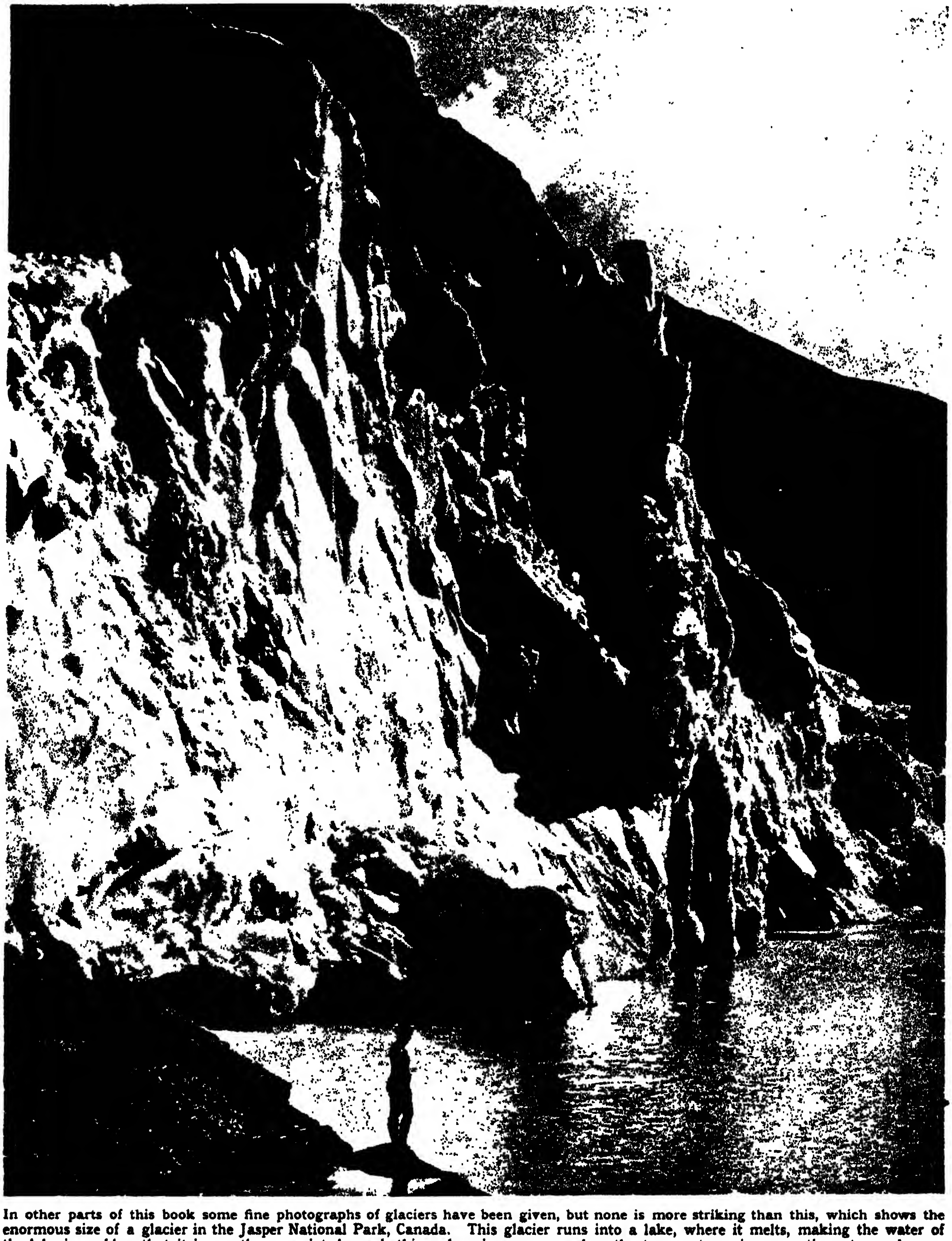
Some interesting experiments can be made with a penknife and some pieces of wood by carving the wood in such a way as to throw shadows upon the wall representing faces. The last picture gives some examples of these. In troubled political times in France people often carried a piece of carved wood which would throw a shadow of their favourite sovereign upon the wall when held near a light.

Sometimes the treasonable toy was small enough to go in the pocket, while at other times the carving was on the handle of a walking-stick carried in the hand.

HOW THE INVISIBLE X-RAYS ARE PRODUCED

This picture shows in simplified form the Crookes tube, invented in 1879 by Sir William Crookes, the famous English scientist. It is by means of this apparatus that the X-rays, which penetrate all sorts of opaque substances, are produced. The air has to be exhausted from the tube so that there is less than a millionth of the usual atmosphere inside. The tube contains a concave aluminium disc known as a cathode, and there are two other discs connected by a wire known as anodes. The cathode is really a negative electrode, and the anode is the positive electrode, and when a current of high voltage is passed through the tube, a strange thing happens. The minute amount of air in the tube glows brightly, and a stream of electrons is shot out from the surface of the cathode or negative pole of the tube, and these are focused so as to fall upon a piece of resistant material such as tungsten known as an anti-cathode, which is really one of the anodes of the tube. The impact has a striking effect. Rays of energy are shot out which will pass through various opaque materials. They are very powerful, although they are not visible to the eye. As their nature was not known when they were first discovered they were called X-rays, X being the symbol of the unknown, and sometimes they are spoken of as Röntgen rays, after their discoverer, Professor Röntgen. For various purposes X-rays of different penetrating power are needed. These are obtained in this way. A roll of mica contained in a glass chamber is connected with wires, and when these are joined up to the cathode and anode the wire is heated and the mica gives off gas which enters the X-ray tube reducing the vacuum, and giving X-rays of less penetration.

A TOWERING PRECIPICE OF MOVING ICE



In other parts of this book some fine photographs of glaciers have been given, but none is more striking than this, which shows the enormous size of a glacier in the Jasper National Park, Canada. This glacier runs into a lake, where it melts, making the water of the lake icy cold so that it is greatly appreciated as a bathing place in summer, when the temperature rises sometimes to 90 degrees in the shade. As can be seen, the end of the glacier where it reaches the lake is a towering precipice of rock, that rock being ice

RADIO PROGRAMMES BOUNCE TO YOUR RECEIVER

WITH a good receiver a radio station broadcasting sound programmes can be picked up at practically any distance from the transmitter, but television programmes can be seen only at a comparatively short distance from the transmitter. Why is this?

Television's short range, seldom more than 70 miles, is due to the simple fact that the earth is the wrong shape for long-range television. If the earth were flat, there is no technical reason why a television programme from any particular transmitter could not be seen on the nation-wide scale now accepted as a commonplace in sound broadcasting.

Sound is broadcast on what are called long, medium or short waves, and these spread out from the transmitter in all directions both upwards from, and at right angles to, the transmitting aerial. The waves broadcast at right angles to the transmitting aerial are picked up directly by receiving sets at distances which are only slightly bent out of a straight line from the transmitter by the curvature of the earth; this distance is about 35 miles. Of course, the higher the transmitting aerial, the greater is the distance at which the direct waves will be best received.

All types of radio waves follow a direct line, and in theory should pass in a direct line from the transmitter, across the surface of the earth until it curves away from the transmitter, and then out into space. And this is what the waves carrying a sound broadcast would do were it not for a region of the atmosphere called the ionosphere or Heaviside layer.

As explained in page 801, the ionosphere is a region of air beginning at a height of about 60 miles above the surface of the earth. Under the influence of the ultra-violet rays from the sun, the gases in the Heaviside layer are ionized; that is, the molecules of the gases are broken into atoms which have positive and negative charges, instead of being electrically neutral. As a result, the atoms of gas have free electrons, and the effect of these is to provide a barrier against the radio waves carrying a sound broadcast.

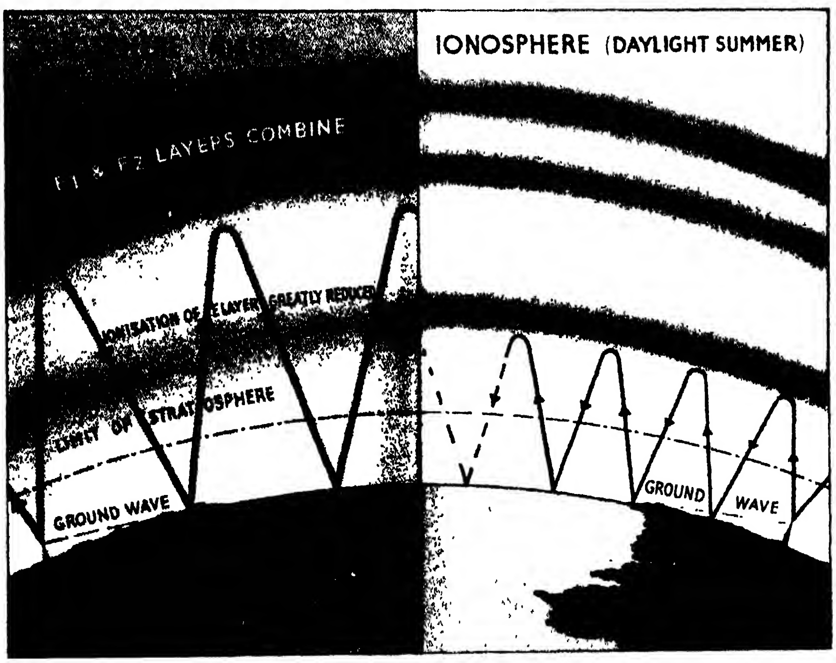
Not only does the Heaviside layer stop the radio waves carrying sound broadcasts, but it acts as a sounding board and echoes or reflects the waves back to the earth. It is much the same thing as a rubber ball being bounced off a wall.

The lower region of the Heaviside layer, called by scientists the E layer, is comparatively lightly ionized, but in its upper reaches (about 200 miles above the earth), sometimes called the Appleton layer or F layer, the gases are very heavily ionized, and contain many more free electrons.

Consequently the Heaviside layer's power of reflecting radio waves back to earth becomes greater with increasing height, and causes radio waves to be spread over a large area of the earth.

Moreover, the waves carrying a sound transmission will be reflected or "bounced" back and forth several times between the earth and the Heaviside layer; just as a rubber ball will bounce a considerable distance along the ground.

Although you may not realize the fact when listening, the wave bringing your programme is not reaching you direct from the transmitting station. It has been reflected to and fro between the earth and the Heaviside layer several times before it was picked up on your receiver; particularly if you live beyond the horizon of the transmitting station.



This diagram shows you the Heaviside and other layers of the ionosphere which, as explained in the article on this page, bounce radio programmes to your receiver.

Not all the waves carrying sound broadcasts are reflected back; a certain proportion pass through the Heaviside layer or are absorbed by it. The proportion thus lost to the earth depends upon the height and density of the layer, which are in turn governed by the season of the year, the conditions on the sun, and whether the broadcast is taking place in daylight or at night.

At night the Heaviside layer is always more heavily ionized and reflects more strongly. That is why short-wave broadcasts are received more clearly during the hours of darkness. In summer, the upper reaches, or F layer, may split into what are known as F1 and F2 layers and the average ionization of the layer becomes weaker and reflects less strongly.

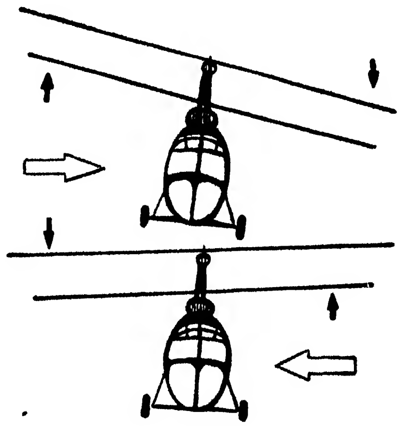
When there is a lot of sunspot activity there is less reflection of the radio waves, and the reception of sound broadcasts by receivers a long way from the transmitter is poor.

By increasing the power of the transmitter, the bouncing of the radio waves between the earth and the Heaviside layer can be greatly increased and the reception distance between transmitter and receiver is extended. Increasing transmitting power is simply a matter of pushing the waves, and the greater the power or push behind sound carrying radio waves the harder they bounce and therefore the farther they will travel.

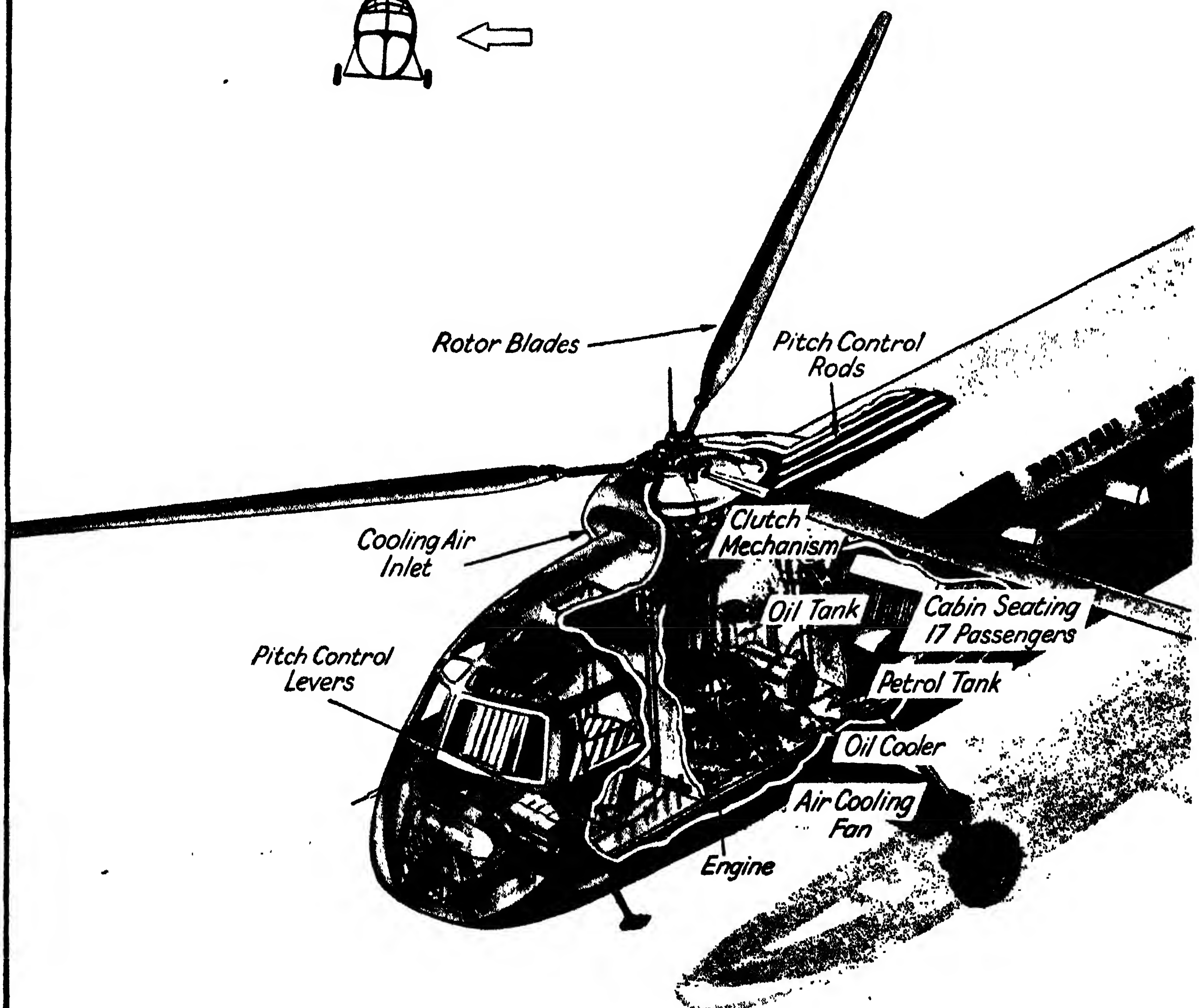
Television transmission must be on ultra-short or ultra high-frequency waves. And unfortunately nearly all of the ultra-short waves carrying a television broadcast are either so weak relative to the electrons in the Heaviside layer that they are absorbed by it or just pass through. It is just the same thing as a very small fish passing through a large-mesh net.

Very occasionally, when height and density of the Heaviside layer are favourable, a small proportion of the ultra-short waves are reflected back, but with their strength greatly weakened. This explains why television broadcasts are on rare occasions seen 100 miles from the transmitter.

AIRCRAFT WITHOUT WINGS THAT DOES

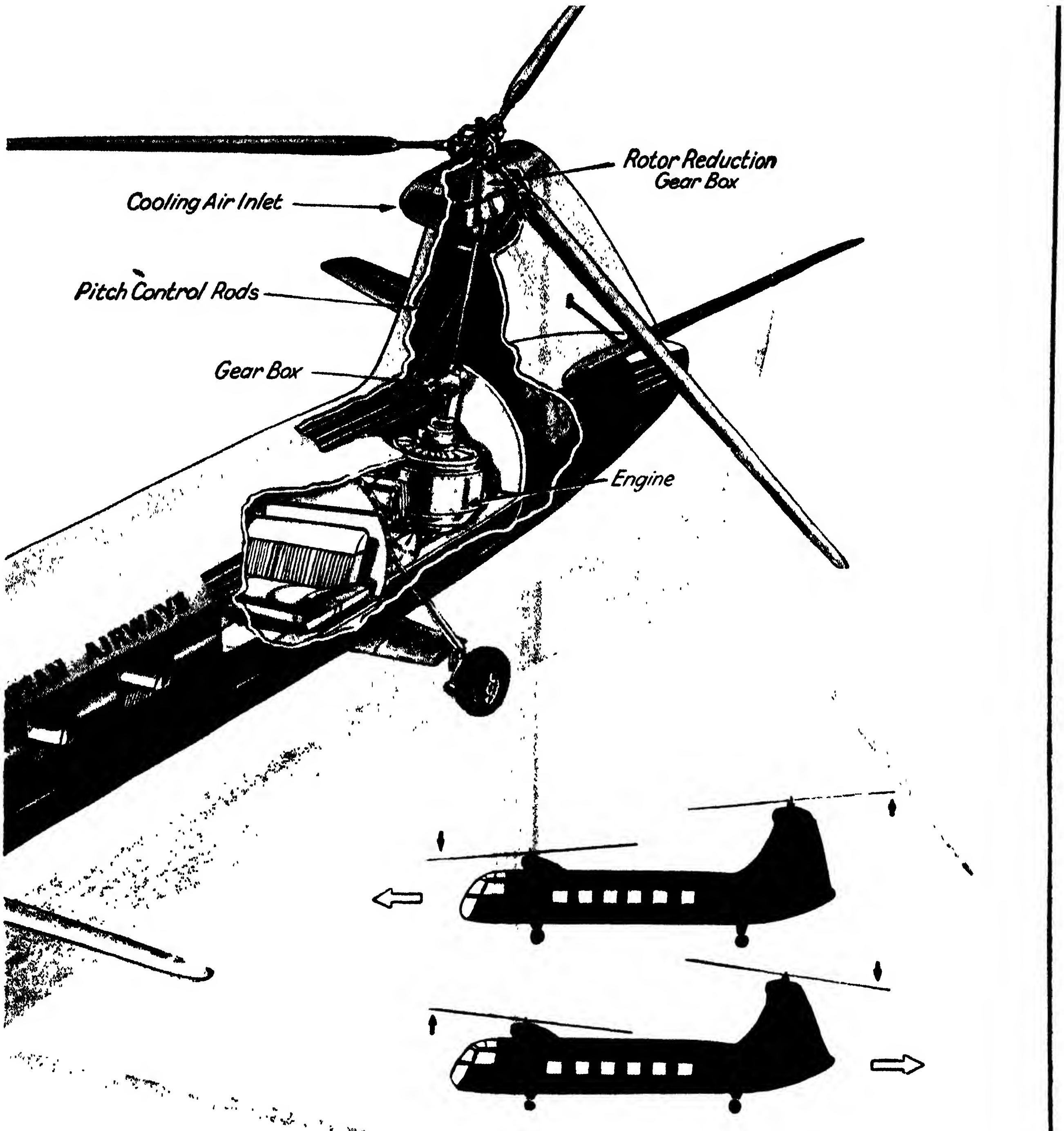


Unlike the aeroplane with wings, the helicopter does not have a rudder but is turned to left or right by changing the angle of the rotor blades. The rotor blades are mounted on a swivelled hub so that they can be swung sideways, backwards or forwards. When the pilot wants to turn to the right, he moves a control lever to the right. This causes the rotors to take up the position shown in the top left-hand sketch. To turn to the left the control lever is pushed in the opposite direction, moving the rotor arms accordingly, as in the lower left-hand sketch.



This drawing shows you a twin-rotor helicopter of the type used by British European Airways for experimental flights in 1952. It is manned by a crew of three and can carry three tons of cargo or 14 passengers. The great advantages of the helicopter over winged aircraft are : its rotors screw into the air so that it can take off or land on a space no greater than the surface area of its undercarriage ; it can safely travel more slowly than an aeroplane ; and it can hover above any particular place. The chief disadvantage of the helicopter is that it is very slow compared with the ordinary aeroplane. Because it does not need a runway the helicopter is the only aircraft that can bring air travellers into the centre of a large city. With

NOT NEED AN AERODROME TO LAND ON



Aeroplanes with wings climb higher or lose height by turning up or down elevators on the tail. Because of its hinged rotors, the helicopter is able to move up or down in the air without elevators. When the pilot wants to gain height he pulls the control lever towards him, so causing the rotor blades to tilt backwards on their hubs: this gives the blades greater surface to " bite " into the air and so screw their way upwards, as in the bottom sketch. To descend, the pilot pushes the control lever from him, so making the rotor blades tilt forward and thus offer less surface to the air, as in the top sketch: this causes the helicopter to glide towards the ground.

aeroplanes much of the saving of time and fast travel in the air is lost on the long journeys by road to and from airports, which, because of their size, must be situated some distance from towns. On account of its ability safely to fly slowly, to hover, or to fly at low speeds near the ground, the helicopter has many uses besides carrying passengers. Helicopters have been used for laying electricity cables across rough country, as you can see in the photograph on page 1420; for dusting crops with fertilisers; and for blowing rain off fruit trees by flying low over orchards and " brushing " off the raindrops by the downward rush of the air from the rotors. Marooned keepers frequently have been rescued from lighthouses by helicopter.

HOW A RIVER WEARS AWAY THE LAND

This photograph showing part of the Delaware River in America illustrates how a river wears away the land and sculptures its own bed. One can see how the water has carved away the bank, leaving islands in the middle of the course which themselves are gradually being worn away. This is what is going on all over the world, where the rivers are flowing away into other rivers or into the sea

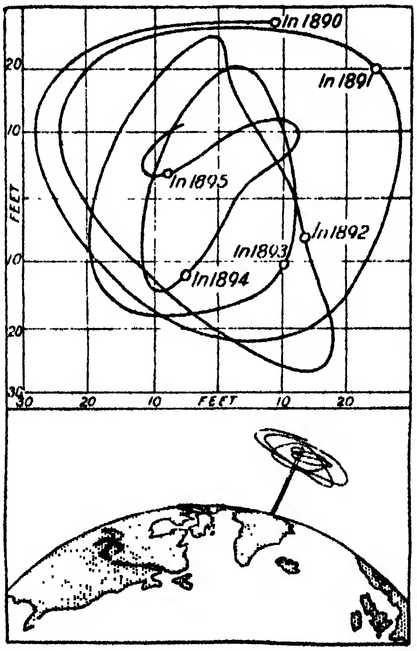
HOW THE EARTH'S AXIS CHANGES ITS POSITION

Most people think that the position of the Earth's axis with regard to its surface remains unchanged, but this is not the case, and even so far back as 2,000 years ago such variations were believed to take place.

A change of axis means changes of latitude also. In the past these changes have been much more marked than at the present time. Professor G. H. Darwin, who made a careful study of the subject, says that the varying distributions of land and sea which the geological records indicate make it quite probable that the axis has changed its position about three degrees, and when the Earth was sufficiently plastic to be deformed by earthquakes it is quite possible that the changes may have amounted to as much as fifteen degrees.

The past, however, is a matter of theory. We can be more sure of present changes, and very careful mathematical calculations demonstrate that changes in the position of the Earth's axis do actually occur.

Dr. Küstner of Berlin, who started a series of observations in 1884, found that the latitude of Berlin was slightly greater from August to November, 1884, than from March to May in 1884 and 1885. The change was very minute, not enough to affect ordinary matters, but there was great interest among scientists at the news, and the statements of Dr. Küstner were carefully tested Further observations showed conclusively that the movement of the Earth's axis of rotation does actually take place.



The path traced out by the movements of the Earth's axis over a period of five years. In the lower diagram the movements are, of course, much exaggerated for the sake of clearness

The changes appear to be very irregular, both in the amount of change and in the period over which they occur. But a cycle would seem to be completed about every seven years.

The diagrams on this page give some indication of these changes in the Earth's axis. In the bottom picture the line showing the changes is enormously exaggerated so that we may see them. It is only a matter of feet. The upper diagram shows actually the movements of the North Pole, and the greatest change in its position does not amount to more than sixty feet.

For a small part of this line of change the line had to be drawn from inference, as there were insufficient observations to be absolutely sure of it. But this applies only to a small part of the movements in the year 1891, and a still smaller part in 1893.

When we remember the size of the Earth these movements of the axis are very small indeed, but they are of great interest to geographers.

THE END OF THE GREAT MUTINY

When, as the result of amazing heroism the Great Mutiny was suppressed and British rule re-established in India, the government of that vast Dependency was put on a sounder and more stable basis than it had ever been before. The Sovereign of England was proclaimed Empress of India, and the Governor-General became her Viceroy. Here is the thrilling story of how the Mutiny was crushed

THE recovery of India from the grip of the mutineers, when the British Empire in the East was at stake, is a great epic of heroic deeds and super-human effort.

The suppression of the Mutiny was due in the first place to leaders like Sir Henry Lawrence, Sir Henry Havelock, Sir Colin Campbell, Sir James Outram, Sir John (afterwards Lord) Lawrence and General John Nicholson; and in the second place to the amazing bravery and endurance of the small body of British troops in India.

It was fortunate that a man like Sir Henry Lawrence was in charge at Lucknow instead of a man of the type of General Hewitt of Meerut or General Wheeler of Cawnpore. Lucknow stood firm against the mutineers, and that fact played a large part in preventing the revolt from spreading more than it did, and in the ultimate re-establishment of the British power in Northern India.

The Mutiny at Lucknow began at nine o'clock on the night of May 30th, 1857. Lawrence had had warning, and when the Residency guard, made up of disloyal sepoys, came on parade, Lawrence with his staff was waiting on horseback to receive them. The English captain asked Lawrence if the men should load their muskets as usual and Lawrence replied, "Yes, let them load."

Calmness Wins

The men drove home their ramrods, and then there was no question that they had the Residency staff absolutely at their mercy. But those brave British officers showed not a sign of fear, and their stern calmness cowed the mutineers, who at the word of command swung round and marched away.

Dr. Fitchett, the historian of the Mutiny, explains how Lucknow escaped while Cawnpore perished. "Wheeler and Lawrence had each to face practically the same situation, and with resources not very unequal. Wheeler's credulous faith in his sepoys flung away the last chance of the ill-fated British in Cawnpore. It was this which made him gather them within those thin lines of earth, shelterless from storm or sunstroke and without supplies, where no fate except death or surrender was possible.

"Lawrence, with surer insight, measured the problem before him. He chose wisely the spot where the British must make their stand for existence. He gathered within the lines he selected all the treasure and war-like resources of the city, with supplies that a siege of five months did not exhaust, and his splendid foresight and energy saved Lucknow."

Lawrence had about 700 European soldiers, and there were 7,000 sepoys, most of whom were known to be mutinous. But beyond the Residency and its precincts lay a great fanatical city, with a population of about 700,000.

Lawrence, a man of great insight as well as forethought, rightly appreciated the possibilities. He told Colonel Wilson that nearly the whole army would mutiny, but not, he thought, the Sikhs, and that in every native regiment there was a residuum of loyal sepoys, whom he meant if possible to retain. As a matter of fact, some 700 sepoys remained loyal, and served through the siege of Lucknow with a courage and devotion beyond praise.

When a Hindu notable advised Lawrence that a number of sacred monkeys should be collected in the Residency, there to be attended and fed by high caste Brahmins, so that the favour of the Hindu gods might be secured for the English, Lawrence replied, "Your advice is good. Come, I will show you my monkeys."

He led the Hindu to a battery of guns and, laying his hand on an 18-pounder, said, "See, here is one of my monkeys. That is his food," pointing to a pile of shot, "and this," laying his hand on the shoulder of a sentry, "is the man who feeds them. Now go and tell your friends about my monkeys."

Pointing to an eighteen-pounder gun, Sir Henry Lawrence said to the Hindu, "See, here is one of my monkeys, and there," indicating a pile of shot, is his food, and this is the man who feeds them"

A Bold Attack

As soon as Lawrence heard that revolted regiments from Eastern Oude were marching on Lucknow, he gathered a little force of 300 British troops, 230 sepoys, 120 native cavalry, 36 British volunteers on horseback, and ten guns, of which six were manned by sepoys, and went out to attack the approaching rebels, who were reckoned to number about 5,000. Actually they were about 15,000 strong, and had 30 guns with them.

The British troops in Lawrence's force marched without having had a meal for hours, and owing to a mistake supplies of food and water did not follow them. But though exhausted by heat, thirst and hunger they attacked the mutineers vigorously. The native cavalry, however, fled, and the sepoy artillerymen deserted to the enemy. The British, it seems astonishing to relate, were armed with weapons

inferior to those of the rebels, and they had to fall back while many men dropped from sheer exhaustion and others from the effects of sunstroke.

An officer who was present tells us that as the British retreated the plain all round them was one moving mass of men. Regiment after regiment of the sepoys poured steadily towards them, and under the deadly fire of the mutineers the heroic band of British soldiers melted away. Wherever the fire was hottest, there Lawrence rode among the men with his hat in his hand, cheering them forward

At last the retreating column reached an iron bridge. The sepoys outnumbered them by hundreds to one, and it looked as though the whole force would be annihilated. The enemy were about to rush the bridge, but Lawrence ordered his empty guns to be placed in line across the bridge, and told the gunners to stand beside them with lighted port-fires.

On came the sepoy host, but when they saw those menacing guns they halted, and Lawrence was thus able to withdraw his force into the Residency Had the mutineers only known that the guns were unloaded, and that the British were without ammunition, they would have swarmed over the bridge and wiped out the entire force.

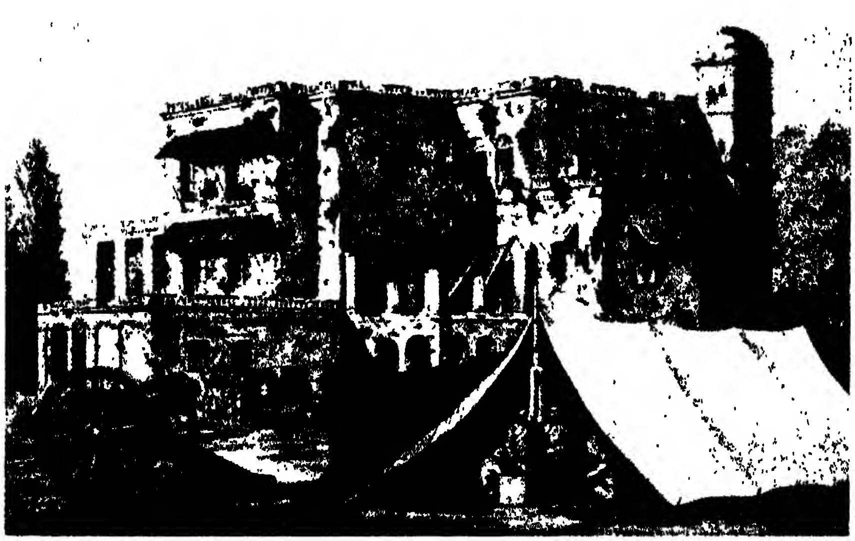
There were many women and children in Lucknow, and right through the terrible months that followed they were as brave as the men. Not far from the Residency was a building known as the Mutchee Bhawan, which Lawrence had decided to hold, but his losses in the recent expedition made it now impossible to do so, and a message was sent to the garrison by semaphore from the Residency roof: "Retire to-night at twelve. Blow up well."

Colonel Palmer, who was in charge at the Mutchee Bhawan, was equal to the situation. He gathered together into a huge pile 250 barrels of gunpowder and nearly a million cartridges, and after spiking every gun that could not be carried away, set a train and lighted a fuse. Then the garrison crept out silently to the Residency.

Suddenly there was a terrific upheaval. The gunpowder and cartridges had exploded, carrying the Mutchee Bhawan with them.

An amazing incident attended this explosion. A British private had, unknown to his comrades, been left behind asleep in the building. He went up, of course, with everything else, when the gunpowder exploded, but in some miraculous way escaped serious injury. The next morning he was found standing naked at the gate of the Residency and hammering for admission.

The Residency quarters, in which the whole of the British, military and civilians, men, women and children, were gathered, consisted of a group of houses and gardens covering an area of about 33 acres. In the centre stood the Residency itself, a three-storey building with windows and verandahs all round.



The Residency at Lucknow after the recapture of the city, showing the damage done to the building by the fire of the mutineers

Trenches were dug and earthworks thrown up in the grounds and the exterior defences were divided into 17 posts, each with an officer in charge, and a small garrison of British soldiers or civilians, with a few of the sepoys who had remained faithful. Every man was on duty day and night, and if he threw himself down for an hour's slumber he kept his loaded musket by his side.

A Man of Character

The sepoys had a saying that "when Lawrence Sahib had looked once down to the ground and once up to the sky and stroked his beard, he knew what to do." It was a shrewd summary of Lawrence's character.

Never was a man in a more difficult situation. Even counting the civilians, who were mostly clerks, he had only 900 British men, and the 700 sepoys were as yet of doubtful loyalty. In addition there were 700 native servants, whose behaviour could not be foretold, and the garrison was handicapped by having with it 600 European women and children.

But Lawrence knew exactly how to distribute his meagre force. As the Residency was closely invested by native buildings all round, he attempted to clear these away and sent out workmen with tools and gunpowder for the purpose. But he was able to blow away only the upper storeys of the buildings. This was of great assistance to the defence, for it prevented a galling fire being directed from them down into the Residency.

The mutineers began the siege of the Residency on July 1st. Their numbers are said at times to have been 100,000, and an official report tells us that there could not have been less than 8,000 men firing at one time into the enclosure.

On the 2nd a shell from a howitzer broke into the room where Lawrence was lying on a bed, and exploded. A group of officers was gathered in the room, but none of these was injured. Lawrence, however, was struck, and the lower part of his body shattered. "I am killed," he said, and the others realised that a real tragedy had happened.

He died on the morning of July 4th, but during those 36 hours in which he lay in agony, he never forgot the people for whose defence he was responsible, or the great Empire of which he was such a distinguished servant.

"Never surrender," was his dying counsel to those round about him. He named Major Banks as his successor, dictated exact instructions about the method of defence to be followed out, and even described how the health of the English might be maintained.

"Let every man," he said, "die at his post, but never make terms."

Then he expressed a wish to partake of the sacrament, and a service was held by the chaplain on the open verandah amid the crackling of the hostile muskets and the crash of the cannon balls as they poured into the enclosure.

In a low voice Lawrence dictated his own epitaph. "Here lies Henry Lawrence, who tried to do his duty. May God have mercy on him," and then he passed away. They buried him that same night.

The feelings of the garrison must have been very much like those of the retreating army of Sir John Moore at Corunna when their gallant commander was buried darkly at the dead of night, while the enemy's guns thundered not far away.

But Lawrence had inspired the members of the garrison with his own

spirit, and for nearly three months they held out with dauntless intrepidity while waiting for the reinforcements that seemed as though they would never come.

Astounding deeds of bravery were performed. A private of the 32nd Regiment, an Irishman named Cooney, one day with a single comrade charged into an enemy's battery shouting as he leapt over a parapet "Right and left extend." The sepoys, imagining a strong body of troops was following, fled instantly, leaving Cooney and his comrade to spike the guns. Cooney was often wounded, but whenever there was a sortie he would leave his bed to take part in it. He was a born fighter

Brave Men and Brave Women

There was no way by which the garrison could get news from outside except through messages from the enemy, who gave them to understand that they were the last Englishmen left in India.

"This might or might not be the case," says Dr. Fayrer, the resident surgeon, "but the garrison determined grimly that if they were the last of their race they would not disgrace it."

When the sepoys dropped shell after shell from a mortar on to one particular house, the ladies kept up their courage by singing part-songs in the portico, to the accompaniment of thundering shells and whistling musket balls.

"During the whole siege," says Mr. Frederick Gubbins, a civilian judge inside the Residency, "I never heard of a man among the Europeans who played the coward."

The civilians were as brave as the soldiers. They fought as though they had been warriors all their lives. Gubbins himself saved the Residency at one critical moment when the sepoys had dug through a wall and found their way into a lane skirting the compound. With his musket stuck through a loophole he shot down every sepoy who tried to cross the lane, and thus held the position for two hours while the British defences were hurriedly built up again.

The garrison engineer, Captain Fulton, performed wonders of technical defence in mining and countermining. Once when the mutineers drove a mine close up to the wall of a house, and he could hear the sound of their picks, he thought this such impudence that instead of countermining, he says, "I just put my head over the wall and called out in Hindustani a trifle of abuse, and 'Fly, fly!' when such a scuffle and bolt took place that I could not leave for half an hour for laughing They dropped it for good, that was the best of the joke"

Meanwhile, what was being done to relieve the gallant garrison? Leaving 300 men under General Neill to hold Cawnpore, Havelock, on July 25th, with a small force of 1,500 men, of whom only 1,200 were British, set out with 10 small cannon and 60 horsemen to relieve Lucknow

Racing to the Attack

Heavy rains had swollen the Ganges, so that it took him four days to get his little force across the river. The infantry out-marched the guns, and when they reached the village of Onao, which was held by the mutineers, the Highlanders and Fusiliers clamoured to attack the place without waiting for the guns to come up.

Havelock agreed, and the Scotsmen and Englishmen raced one another to get into the village first Every house had been turned into a loopholed fortress, but the British took the village, and pursuing the flying enemy's guns captured them also Then a walled town had to be taken, and by the time it was captured a third of Havelock's ammunition had been used, and a sixth of his force had succumbed to gunfire or disease

To make matters worse, he heard that Cawnpore in his rear was threatened, and that the Mutiny had broken out at various other places

A Call for Reinforcements

Havelock telegraphed to Calcutta that he could not continue his march to Lucknow till he was reinforced by 1,000 infantry and a battery of guns, but as soon as a single company and two guns joined him on August 4th he started once more. But although he won a victory he could not continue, as every fourth man under his command was disabled by wounds or sickness He therefore fell back on Cawnpore.

By September 16th, after reinforcements had joined him, he felt ready to start once more for the relief of Lucknow. But just as success seemed within his reach, General James Outram arrived to take command of the forces.

It was a cruel blow for Havelock thus to be superseded by a superior officer, but Outram, who has been called the "Bayard of India," with great chivalry confined himself to his civil office as Commissioner, and placed himself as a volunteer under Havelock's orders till the relief should be accomplished, so that Havelock might have the glory and honour of it. It was one of the finest incidents of the great Mutiny

Once again Havelock crossed the Ganges, this time with a force of 3,000

The dramatic meeting of Sir Henry Havelock, General Outram and Sir Colin Campbell after the relief of the Residency at Lucknow. From the well-known painting by Thomas Jones Barker

men. Rain fell almost continuously and the country was like a quagmire, but the gallant force went forward, and when they came upon the sepoys entrenched in a village, defeated them. Outram riding forward with nothing in his hand but a gold-mounted cane, with which we are told he thumped the heads and shoulders of the flying enemy. When some mutineers who had committed horrible cruelties upon defenceless women and children fell into Havelock's hands, he blew them from the mouths of his guns.

At last the relieving force came within sound of the guns of the besiegers at Lucknow, and Havelock ordered a royal salute to be fired, in the hope that the beleaguered garrison would hear it and take courage. There was little wind at the time, however, and the sound did not carry so far as the Residency.

On September 23rd Havelock's force had reached the suburbs of Lucknow, and there he defeated a large army of mutineers in a garden known as the Alumbagh. In a very short time 1,200 rebels were in flight, and then Havelock rested his men for 24 hours, while he planned the advance on the Residency.

A Triumphant Entry

On September 25th the advance was made amid a deadly and unremitting fire from houses on both sides of the streets, and from guns which commanded the approaches. Havelock's men fell fast. A musket ball passed through Outram's arm, but he only smiled and asked one of his officers to tie a handkerchief tightly above the wound.

The marvel is that any of the British force survived that terrible march. But slowly the houses were captured, the sepoys driven from them, and at last on the evening of the same day the Residency was reached. And then through an opening in an earthwork before one of the gates rode Outram on a large horse, followed by Havelock and his Highlanders, with his staff, and the Sikhs and Fusiliers. A great shout of welcome rose from both the beleaguered and the relieving troops. Even the women and the children, and the sick in the hospital, joined in the shout.

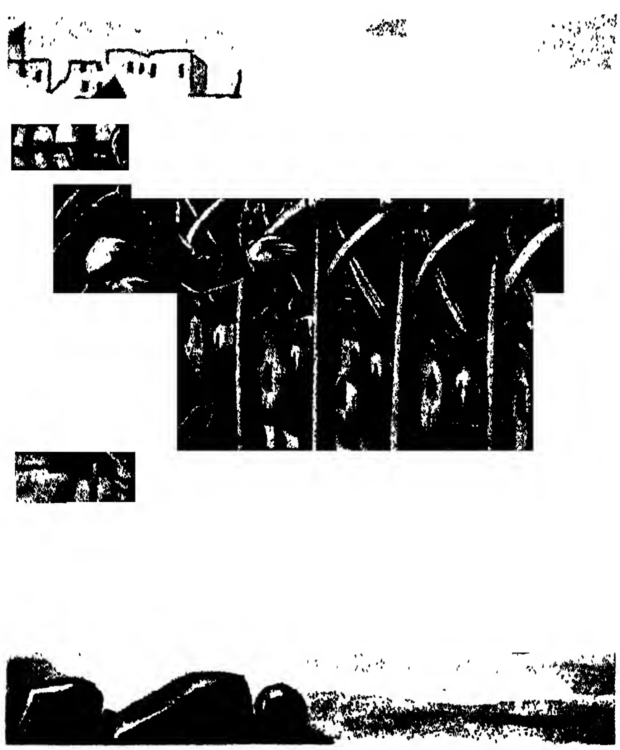
The big, rough-bearded soldiers, we are told, seized the little children out of the arms of the ladies and kissed them with tears running down their cheeks. They thanked God that they had arrived in time to save these from the fate of the women and children at Cawnpore. "We expected to have found only your bones," said one of the soft-hearted Highlanders, as he joyfully snatched up a child.

For nearly ninety days the garrison had been besieged, but never once had the British flag ceased to fly over the Residency.

The garrison was relieved, but at a great cost. Of the 3,000 men of the relieving force more than 700 or nearly one in every four had been killed or wounded. It was rather a reinforcement than a relief, for the sepoys still kept up a tireless fire on the Residency.

Outram now took command, and for six weeks the strengthened garrison held its own against the swarms of mutineers who still blockaded the Residency.

But by November reinforcements were arriving from England, and Sir Colin Campbell, a distinguished soldier, had come out as Commander-in-Chief. He reached Cawnpore on November 3rd, and on the 9th set out for the relief of Lucknow. It was thought, though incorrectly, that the garrison had food for not more than five or six days.



Sir Colin Campbell, addressing his Highlanders, said, "You must reach Cawnpore to-night at all costs"

The relieving force was only 5,000 strong, but of the most magnificent fighting quality. On November 12th, Campbell had reached the Alumbagh, and then by dint of hard fighting, position after position was carried, till at last a building known as the Mess-house, not far from the Residency, was reached.

From the summit a Union Jack was hoisted as a signal to the beleaguered garrison, but the sepoys directed their fire upon this and twice shot it down.

Signals were then sent from another building surmounted by a dome. An adjutant, a sergeant and a little drummer-boy named Ross, twelve years old and small for his age, climbed to the very top of this dome, put a Highland bonnet on the top of a staff and waved the regimental colour of the 93rd regiment, while the small boy sounded the regimental call on his bugle. These signals were seen and answered from the Residency before the sepoys opened a battery on the dome.

The three heroes descended, but little Ross turned round, and running up a ladder held on to the spire of the dome with his left hand, and blew the call known as "The Cock of the North" as a defiance at the enemy. It was a wonderful act of bravery in one so young.

Finally the Residency was reached, and it was then decided to bring away the garrison with the women and children, and to abandon the walls and trenches of the battered Residency to the enemy. There were 600 women and children, and more than a thousand sick and wounded men to be conducted through the midst of a great hostile force, but it was done and done safely.

The Death of a Hero

Four hours after the last Briton had left the Residency the rebels were still pouring a fire upon the enclosure thinking the British were still inside.

The gallant Havelock died from an attack of dysentery as he was being carried out of the building, and his remains lie buried in the Alumbagh, which he had himself won by a daring assault only a few months before. The interior of the Alumbagh is now a garden, and an obelisk marks the spot where the "bravest of the brave" lies buried.

It was no easy task to take back safely to Cawnpore the refugees from Lucknow. The women and children and the wounded with their escort made a procession many miles long, and Campbell's great anxiety was that the bridge of boats which spanned the Ganges at Cawnpore should not be destroyed by the enemy before he arrived, for it was his only possible line of retreat.

He had left General Windham to guard the bridge and hold Cawnpore with only 500 men, against a rebel force of 25,000 men armed with 40 guns, and commanded by the ablest soldier among the mutineers, Tantia Topi.

It was a terrible situation, for the convoy of refugees could not be saved till the bridge was crossed. No news came from Windham, and then the sound of cannon was heard. It was

clear that the little British force was being attacked and fighting for its life. All through the night the booming went on. If the bridge fell, then not only Windham, but Campbell and all those with him would probably be annihilated.

Captain Forbes-Mitchell tells us how Campbell met the situation. "If the bridge of boats should be captured before we got there we would be cut off in Oude with 50,000 of our enemies in our rear, a well-equipped army of 40,000 men with a powerful train of artillery, numbering over 40 siege guns, in our front, and with all the women and children, sick and wounded, to guard. 'So, 93rd,' said the grand old chief, I don't ask you to undertake this forced march in your present tired condition without good reason. You must reach Cawnpore to-night at all costs.' 'All right, Sir Colin,' shouted one voice after another from the ranks, 'we'll do it!'"

The men had not had their clothes off or even changed their socks for eighteen days. But they dashed forward, and although Windham had been defeated by overwhelming numbers, they saved the bridge and defeated the enemy. The convoy of women, children and sick from Lucknow was carried safely into Cawnpore.

A Symbol of Power

The capture of Delhi by the rebels on May 11th was a great disaster for the British, not because of any particular military value that lay in this city, but because as the capital of the old Mogul Empire it was the great symbol of authority to the people of Northern India.

Nicholson was so respected by the Hindus that a brotherhood of Fakirs renounced all other creeds and devoted themselves to the worship of Nikkul-Seyn. They would lie in wait for him and fall at his feet with votive offerings

With the English turned out of Delhi and the native king, who had formerly enjoyed merely the trappings of royalty, proclaimed sovereign of Hindustan, the mass of the natives in that part of Northern India felt that the reign of the British Raj had really come to an end.

It was therefore essential that if the British power was to be re-established in India, Delhi must be recaptured, and that as quickly as possible.

This great work we owe perhaps more to Sir Henry Lawrence's brother John (afterwards Lord Lawrence) than to any other man. Sir John Lawrence held a difficult position. He was the Chief Commissioner of the Punjab, a country of twenty million inhabitants, which had only recently been conquered by the defeat of the warlike Sikhs, and was held by sepoy regiments now thoroughly disloyal.

What would the Sikhs do? Would they throw in their lot with the sepoys and the whole Punjab blaze up into rebellion?

It might easily have done so, had it not been for Lawrence. He was a man of iron resolution and instant decision Placing the forts, arsenals and treasuries in the Punjab in charge of the few British troops which he had at his command, he organised a mobile column of European troops of the very best quality, which he placed under the command of General Neville Chamberlain, ready to strike instantly at any place where mutiny became active.

Where mutiny actually did break out judgment was swift and the punishment he inflicted terrible. Then the sepoy regiments were disarmed, and Lawrence with great daring built up a new army nearly 50,000 strong composed of the Sikhs, who had so recently been the enemies of Britain.

What a strange position: the conquered people who were supposed to be held in awe by the sepoy regiments which had defeated them under British leadership, themselves became the instruments of re-establishing British rule against those very sepoys.

But as Captain Talboys Wheeler points out, during the few short years that the Sikhs had been under British administration they had not forgotten the miseries that prevailed under their native government, and could appreciate the many blessings they enjoyed under British rule. They stood staunch for the British Government, and expressed their eagerness to be led against the rebels.

Lawrence decided that Delhi must be besieged without an instant's delay. He gathered a force for the purpose, formed a military base at Umballa, a hundred miles away, and arranged to supply the besieging force with men, munitions and food. He reinforced it with his own frontier troops, the famous Guides and Gurkhas, and later on with the mobile column, which he had formed to suppress the mutiny in the Punjab.

The Guides were led by a gallant soldier, Lieutenant Hodson, who later raised a famous regiment of irregular cavalry known as Hodson's Horse, that performed exploits of valour during the suppression of the Mutiny.

Lawrence's efforts were eventually crowned with success. "Through him," wrote Lord Canning, the Governor-General, "Delhi fell," and that was the beginning of the end of the Great Indian Mutiny.

A Fierce Campaign

But it was a fierce and bitter campaign that had to be waged. A small body of British troops was holding the Ridge outside Delhi. Sir Henry Barnard had marched from Alipur and reoccupied the old cantonment, which had been abandoned on May 11th. He had to defeat a large rebel force to do so.

Inside Delhi there were about 30,000 rebel troops with powerful artillery, ample stores of munitions and abundant provisions. The defences of the city covered an area of three square miles. They consisted of a series of bastions 16 feet high, connected by long walls with occasional towers to aid the flanking fire. Every bastion had eleven guns mounted, and both the bastions and the walls were built of masonry 12 feet thick. Running round the base of the bastions and walls was a terrace varying in width from 15 to 30 feet, and having on its outside edge a wall loopholed for musketry.

The whole was surrounded by a ditch 20 feet deep and 25 feet wide. On the eastern side of the city ran the river Jumna, and there was a bridge of boats opposite the city prison near the palace of the king. There were seven gates to the city, and the principal street, the Chandni Chouk, ran from the Delhi Gate to the palace.

The British flag was kept flying on the Ridge, but for weeks nothing could be done to attempt the siege of the city. The besiegers were indeed for a long time really the besieged, for they were exposed to assaults from all sides.

On June 23rd, the 100th anniversary of the battle of Plassey, the rebels made a great effort to carry the British position. They advanced in overwhelming numbers, and for hours there was a deadly struggle. Only after the Sun had set was the enemy compelled to retire, having lost a thousand men

Dr. Fitchett says: "The first reinforcement to arrive took the surprising shape of a baby. One officer alone, Tytler, of the 38th Native Infantry, had brought his wife into the camp; she was too ill to be sent to the rear, and in a rough wagon for bed-chamber, gave birth to a son, who was solemnly named Stanley Delhi Force. The soldiers welcomed the infant with an odd mixture of humour and superstition. A British private was overheard to say, 'Now we shall get our reinforcements. This camp was formed to avenge the blood of innocents, and the first reinforcement sent us is a new-born infant.'"

Similar actions to that described were fought again and again through the early weeks of August. But reinforcements were being sent, and by the middle of August Brigadier John Nicholson, one of the great heroes of the Mutiny period, arrived from the Punjab with a brigade of troops and a siege train. Then in the first week of September a heavy train of artillery was brought up from Ferozepore, and the British force on the Ridge at last exceeded 8,000 men.

The siege began in earnest. Fifty-four heavy guns pounded away at the gates and bastions, and batteries poured in a constant storm of shot and shell.

By September 13th breaches had been made which were reported by the engineer officers to be quite practicable for assault. Nicholson was to lead a column of 1,000 men and carry the breach near the Kashmir Bastion. A second column under Brigadier Jones with 850 men, many of them natives, was to attack the gap near the Water Bastion. A third column 950 strong under Colonel Campbell was to blow in the Kashmir Gate and fight its way into the centre of the city. A fourth column under Major Reid, consisting of Guides and Gurkhas with a few English was to force its way in by the Lahore Gate. A reserve column 1,000 strong under Brigadier Longfield was to render assistance at any point where it might be needed.

At three o'clock in the morning, while the stars were shining, the lesson for the day was read before the men in their tents, and it was regarded as remarkable that it should be the third chapter of the prophet Nahum, where the opening verses run: "Woe to the bloody city! It is full of lies and robbery . . . Behold, I am against thee, saith the Lord of Hosts."

The Taking of the City

There is no space here to describe the wonderful attack upon the city, the amazing gallantry and fearlessness that was shown by all, and the almost superhuman efforts that were made. Suffice it to say that the Kashmir Gate was successfully blown up, and the third column rushed in and pushed towards the centre of the city.

Meanwhile, the first column under Nicholson climbed through the breaches of the Kashmir Bastion, and fought its way along the ramparts towards the Kabul Gate. There it was met by the second column under Brigadier Jones, who had entered through the breach at the Water Bastion.

As they advanced the columns were met by a ceaseless fire from the loop holed houses and mosques, and John Nicholson, the hero of the day, while waving his sword and leading his men up a narrow street, was shot through the body and fell mortally wounded. Raising himself on his elbow he called to his men, "Go on!" and refused all help, so as not to detain any of the fighters. When an officer begged to be allowed to convey him to a place of safety, Nicholson declared that he would allow no man to interrupt his duties so as to remove him, but would die there.

The Kashmir Gate at Delhi, photographed after the recapture of the city The damage done to the walls by the British gunfire can be seen

He was a remarkable personality, a strange mixture of piety and daring bravery. His influence over the natives was marvellous. A brotherhood of Fakirs, we are told, renounced all other creeds and devoted themselves to the worship of "Nikkul-Seyn." They used to lie in wait for Nicholson and fall at his feet with votive offerings, and this despite the fact that Nicholson did his best to cure them of their piety by a sound application of the whip. That, however, to the Fakirs, was only an added proof of his divinity.

Sir Donald Macnab says that when the worshippers of Nikkul-Seyn heard of his death they met together to lament and one of them stood forth and declared that there was no object in living in a world that no longer contained Nikkul-Seyn, and he thereupon committed suicide. The others decided that this would not have been approved by Nikkul-Seyn, and so they decided to learn to worship Nikkul-Seyn's God, and the entire sect actually accepted Christianity.

By September 20th the whole city was in the hands of the British. The rebel troops had fled and the old king, but he was brought back to Delhi by Hodson.

The next day Hodson went out again with a hundred horsemen and captured the two sons of the king in the midst of a great crowd of armed retainers.

Near the city the party was surrounded by a great crowd, and Hodson, who was afraid of a rescue, decided to shoot both the princes, who had been responsible for so much cruelty. He fired at them with his own pistol, while the crowd stood looking on, shuddering at the daring of the Sahib.

It is easy enough for armchair critics to condemn Hodson, but there seems little doubt that these blood-stained villains would have been rescued and escaped had he not carried out what he considered an execution. They certainly deserved their fate.

Little remains to be told. The capture of Delhi was the turning point. Sir John Outram drove the rebels out of Lucknow and re-established British rule in the capital of Oude. Sir Colin Campbell conducted a successful campaign in Oude and Rohilcund, and at last law and order were restored. And on September 1st, 1858, Queen Victoria was proclaimed Empress of India, and the rule of the East India Company ceased.

GRAVITY SHUNTS 4,500 WAGONS A DAY

Like everything else, shunting on the railway has been mechanised and is now done by "mass production," in a few huge marshalling yards. Gravitation is made to assist in moving the wagons so as to save engine power and the actual shunting is controlled from a glass tower, as explained here

The method of shunting and making up trains has been completely revolutionised in recent years. Instead of doing the shunting locally in scores of centres as was formerly the case, the modern way is to have one or two great marshalling yards, where all the trains are made up in a minimum of time and with a minimum of labour.

At these yards the tracks, which often total many miles, are arranged in gridiron fashion, one gridiron being used for the reception of coaches or wagons and the other for the despatch of the trains when made up.

Trains pick up the various wagons at the different stations along the branch and main routes and take them to the marshalling yard where there is a raised part known as a "hump." The wagons are pushed by a powerful engine up the hump, and just before they reach the top are uncoupled by a shunter. Then they run down the other side by gravitation and each is directed into its proper track by a man in a control tower who works the points by switches and can manipulate electric or hydraulic brakes which are on the rails instead of on the wagons. In this way the trains are made up much more quickly than they could be by the old method.

One of these marshalling depots, known as the Whitemoor yard, is at March on the Eastern Region of British Railways. It has fifty miles of track and can deal with 4,500 wagons daily. The movements of the wagons are controlled from two glass-sided towers by four men, and as an example of what can be done it may be mentioned that a train of 50 wagons from over a dozen places can be made up in 10 minutes.

When the wagons have passed over the hump, the sharp descent causes them to draw away from one another rapidly, thereby enabling them to be switched on to whatever line may be desired. The cabin or tower is situated on top of the hump and a complete view of the whole system is obtained through the glass side of the building.

The working of the power-operated switches so as to insure that the trains shall be made up in the proper manner is a highly skilled task and involves great responsibility.

The saving resulting from this new and efficient method of shunting is enormous. In time, in labour, and in engine power almost incredible economies are effected, and the old-fashioned method of shunting locally will soon be obsolete except in a few cases where there are special reasons for retaining that system.

The central tower at the Whitemoor marshalling yard on the Eastern Region of British Railways, where all the shunting and making up of trains is carried out by a man in the tower working switches which alter the points and apply hydraulic or electric brakes attached to the rails. This yard has 40 sidings, totalling fifty miles of track, and deals with 4,500 wagons daily.

THE MODERN ROAD AND HOW IT IS MADE

The Romans were the greatest road-builders that the world had ever seen, up to quite recent times. Wherever they went they built highways which have in many cases lasted down to our own day.

Unfortunately in England as well as in other countries as the centuries went by the roads were allowed to get into disrepair, and by the eighteenth century they were so bad that for months together every year many towns and villages were practically cut off from the rest of the world.

By the beginning of the nineteenth century the road problem was so acute that a great reform was set on foot, and many good highways and by-roads were constructed, which did good service so long as the roads were needed only for horse traffic.

But with the advent of the motor-car it soon became clear that the existing roads had many defects. They were often too narrow and winding and in many cases had steep gradients. Above all, their surfaces were such that the rapidly moving traffic wore them away in a very short time.

Not only did the new mechanical traffic cut the roads to pieces, but the dust that was thus created became intolerable in windy weather, while in the rainy season many of the roads were thickly covered with slush and mud, which dried in ruts.

Nothing could stay the development of mechanical transport, however, and so the roads had to be adapted to the traffic instead of the traffic to the roads. Scientists and engineers set to work to discover what was the best type of road for the new traffic. Entirely different materials were needed for both the foundation and the surface from those used in the old roads; and at last a suitable form of road was evolved which could resist the pressure of heavy vehicles and the rapid motion of mechanically driven transport.

It also came to be realised that the making of great arterial roads was a national business and not a local affair, and in England, America and other countries a great road-making epoch began in which all the latest science was brought into service.

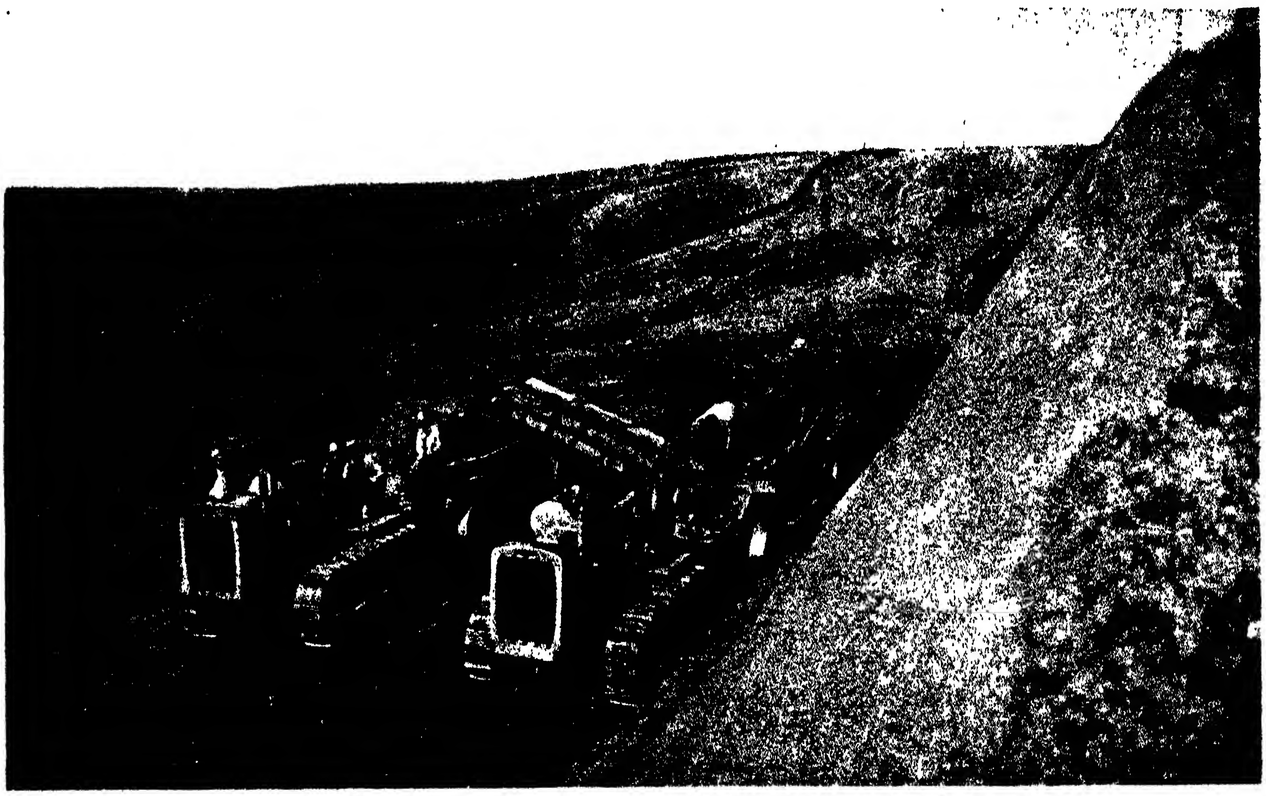
The cutting of a wide arterial road through a difficult country is a big task that needs mechanical appliances of the very latest type. Explosives are used to remove rocky obstructions, mechanical excavators do the work of thousands of men in a tenth of the time, and whereas in the old days thousands of slaves had to work over a long period to make a big road, to-day a road capable of sustaining the heaviest traffic the world has ever seen can be constructed in a few months.

On this page we see some of the machinery used on large-scale road-making. A power-driven excavator scoops away the material, while as fast as it is dug out the material is carried by an endless band conveyor and loaded into a trailer drawn by a caterpillar tractor. The surface on which the road foundation will be laid is smoothed by bulldozers and mechanical scrapers.

The wear and tear of a road occasioned by rapidly moving vehicles bearing heavy loads can hardly be imagined, and it is essential that the foundation of a road shall be made of the strongest material, such as reinforced concrete. Concrete by itself is solid, but has no resilience. That is provided by the steel reinforcement.

Then the surface, while it must be smooth so as to reduce vibration to a minimum, must at the same time be capable of resisting the large amount of friction from the wheels.

For the surface the principle of McAdam of using fragments of hard stone is still followed, but tar is also used as a binder. Some surfaces are of asphalt, which becomes very hard when rolled and cooled. Blast furnace slag, bound with tar, is also used both for the foundation and for the surface.

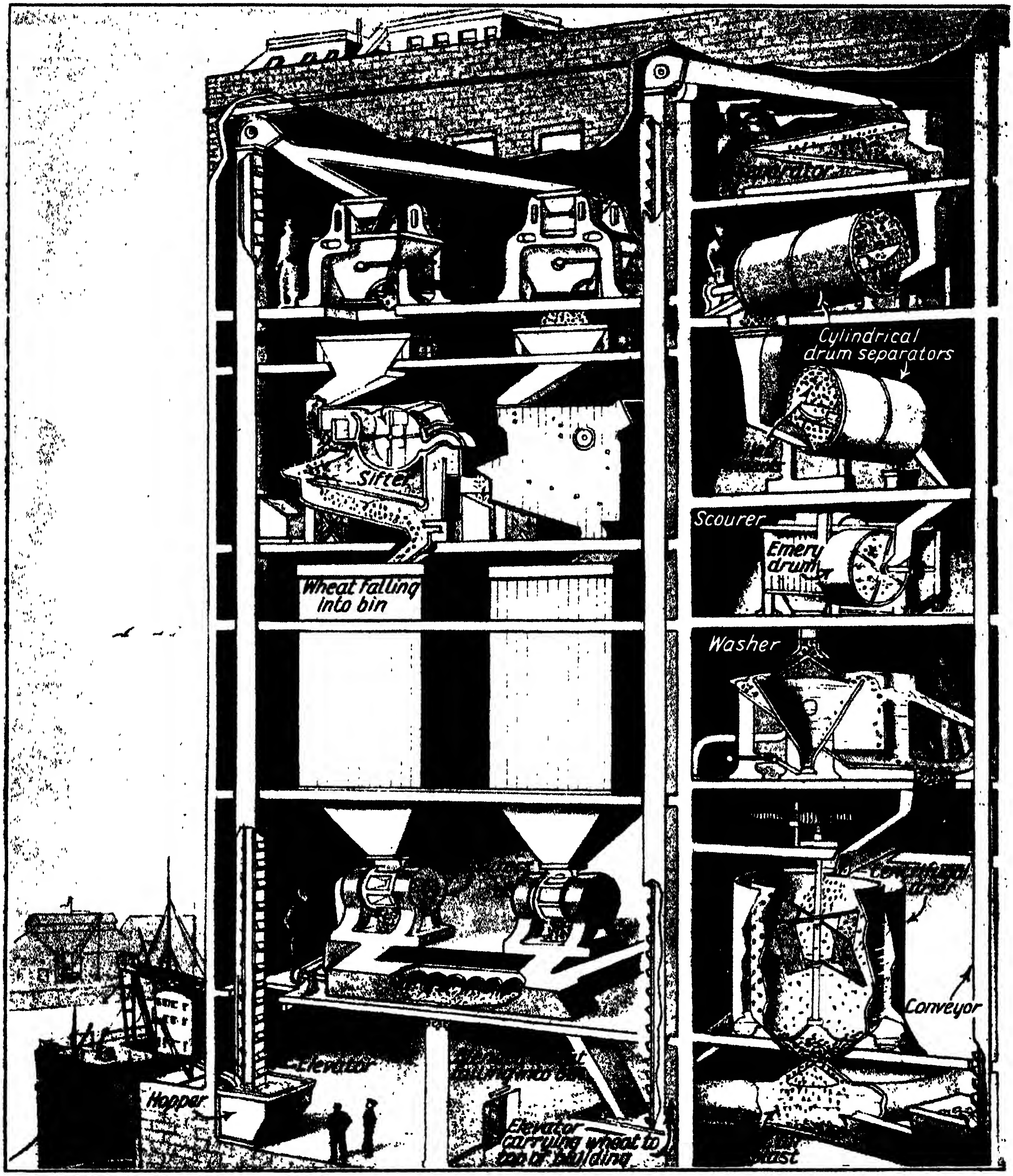


In this photograph we see road-making machines at work. It is a good example of the mechanisation to be found in connection with the making of arterial roads. The power is supplied by two Diesel engines, one driving a caterpillar elevating grader, and the other towing a trailer. While one machine cuts away the earth, the other by its side receives the excavated matter, which is passed to the truck up a continuous chain elevator. These are only two of the many types of road-making machines which do the work of thousands of men in a tenth of the time that would be occupied by the pick and shovel methods of road-making.

THE BIGGEST DRY DOCK IN THE WORLD

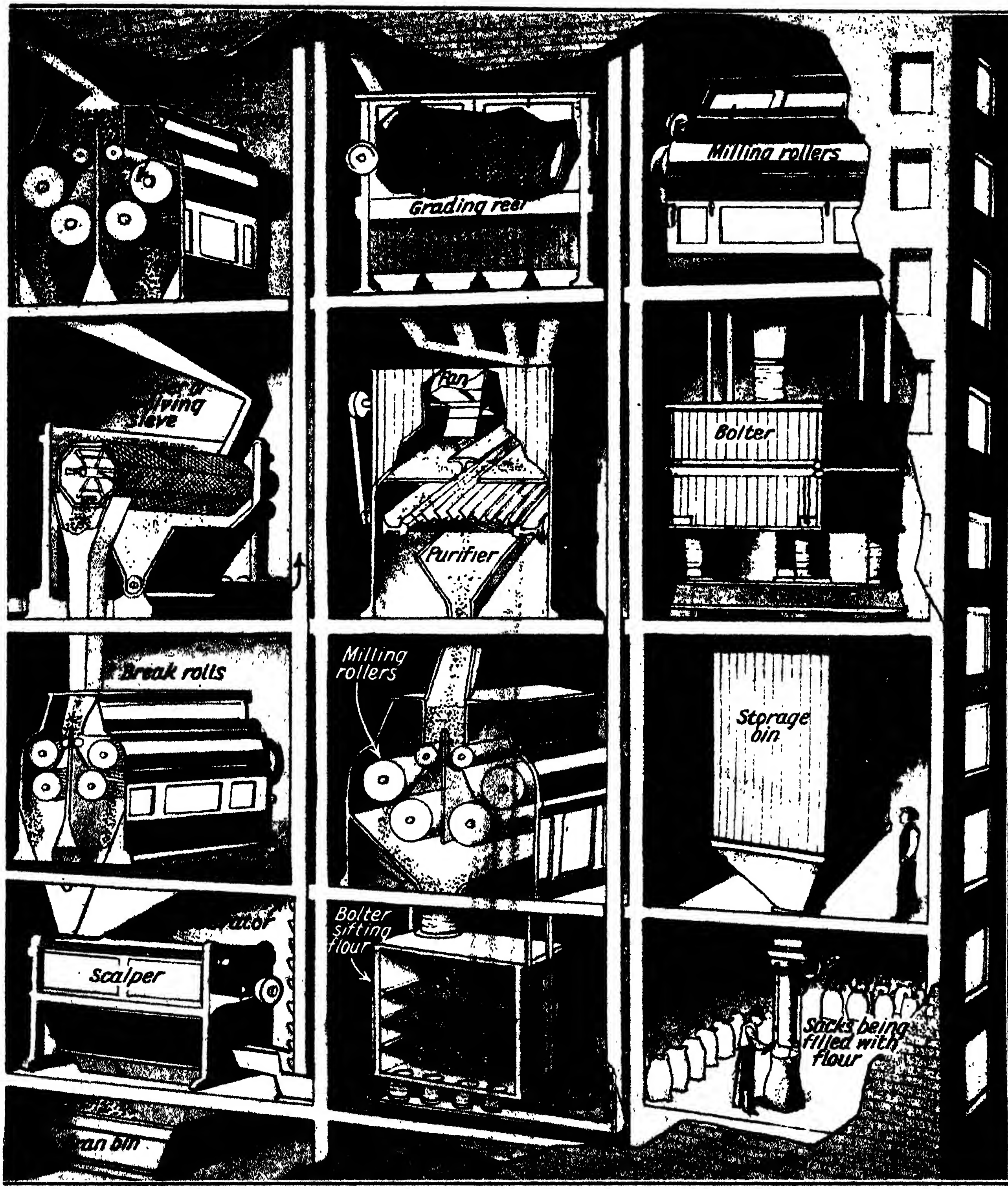
This photograph, taken from the air, shows the world's biggest graving dock at Southampton being opened by King George V in July, 1933. The Royal yacht Victoria and Albert is steaming into the dock after cutting a ribbon stretched across the entrance. The dock was officially named the King George V Graving Dock. It has been constructed with an eye to the future, for while the biggest ship afloat at the time of opening was the Majestic, 56,621 tons and 915 feet long, the dry dock easily accommodates the Queen Elizabeth, which is 1,031 feet long and displaces 85,000 tons. The dock took six years to construct and 20,000,000 tons of material had to be removed.

HOW THE WHEAT IS CLEANED AND GROUND



On these pages we show in simplified form what happens in a large modern flour mill, equipped with the latest machinery for cleaning the wheat and grinding it into flour. The wheat on arriving is delivered into a hopper by a travelling belt, and is carried to the top of the building by a bucket elevator, where it passes through an automatic weigher and thence through a coarse sifting machine. This allows the wheat to pass through a perforated metal covering, while the chaff and dust are blown away by a fan, and stones and other rubbish fall down a slope and are collected outside. The wheat then passes into storage bins, from which it is drawn as required. The wheat from different bins passes through machines which measure out given quantities, and blend various wheats to provide a suitable mixture. The blended wheat then falls into a bin and is carried once again to the top of the building for cleaning. First of all it passes through a separator with a jigging sieve, or shaking platform, of perforated metal. The wheat falls through perforations, but such things as maize, short straws and so on travel on and are collected. The wheat then falls on to a second sieve, the holes of which are too small for a grain of wheat to go through, but large enough for smaller seeds, dust, and so on to pass. A strong current of air blowing through the machine carries away the chaff and lighter dust. The wheat is next fed into a cylindrical drum of metal, the inside of which consists of a large number of drilled indents. These dents are of such a size and shape as will just hold a grain of wheat, but are not big enough to pick up a grain of barley or oats. The wheat is thus picked up and thrown by centrifugal force into a collecting conveyor in the middle of the cylinder, while any barley and oat grains mixed with the wheat are shot along to the end of the machine and delivered into a sack. The wheat passes into another machine of a similar kind, with smaller dents in the discs, and here cockle seeds are separated from the wheat, which

INTO FLOUR READY FOR THE BAKER'S USE



next passes to a scourer, that cleans the skin. This consists of a metal drum lined with emery, and has inside fast revolving beaters which throw the wheat against the emery so that its skin is rubbed clean. A strong current of air carries away the dust and dirt. The wheat is now washed, passing into a shallow tank where stones and sand sink to the bottom, while the wheat is propelled over the end and given a thorough scrubbing by means of a screw conveyor upon which jets of water under high pressure play. It next passes into a centrifugal drier which whizzes it round, the water being thrown out through perforations, and it is then further dried by a blast of hot air. Having been thoroughly cleaned, the wheat is now ready for grinding. It is carried once more by a conveyor to the top of the building and is passed through corrugated steel rollers known as break rolls, which remove the outer covering of the grain. The wheat then passes through a revolving sieve known as a scalper, which separates the large bran from the broken wheat. Again the wheat passes through smooth rollers which break it up still more, and through another scalper, and the process may be repeated half a dozen times. The bran is collected in a bin and the coarse flour is now conveyed once more to the top of the building, where it goes through a grading reel, which divides it up according to size. Then it passes down to a purifier, where the dust is blown from it and the half-ground flour once again drops below and passes through milling rollers, which grind it very fine. It then goes through an apparatus known as a bolter, containing many sieves, which is constantly vibrating so as to shake the flour through the meshes. The fine flour passes through, while the coarser stuff is collected for regrinding. The fine flour is carried to the top of the building again, ground still finer by a further set of rollers, sifted in a bolter, and then passes into a bin to be drawn off and packed into sacks for the market as required

THE GREAT ROMANCE OF A FROG'S LIFE

Here is the romantic life-story of the common frog. After sleeping through the winter the female frog wakes up in spring and lays her eggs at the bottom of a pond or ditch. The eggs are small black globes, each surrounded by a covering of jelly, which soon absorbs water, swells up, and rises to the surface. An egg when magnified is seen to be divided into black and white sections, the white part being a store of food, while the dark part contains the embryo from which a tadpole will be hatched. The eggs change in appearance, and in about a fortnight the tadpoles are hatched out. Many tadpoles collect in clusters on the waterweed, attaching themselves by suckers. Each tadpole lives for a time on the food supply left in its body from the egg, and then a mouth appears. The tadpole now feeds voraciously on a plant diet. When the tadpole is a month old little hind-legs develop and grow, and then fore-legs appear. As the legs grow the tail gets smaller and at last disappears. The frog now lives on tiny insects, and leaves the water, but returns occasionally in dry weather. It is a great jumper, and it is also clever at catching insects with its tongue

THE STRANGE LIFE-STORY OF THE FROG

We do not have to go to remote lands to discover romantic life-stories in the world of nature. There are plenty of them round about us and none is stranger than that of the common frog of our ponds and meadows told here. The changes this creature goes through as it lives its life are very strange and curious

In late February or early March, according to the weather, we hear a loud croaking in the neighbourhood of ponds and marshes. It is the voice of the frogs that have been awakened by the Sun from their winter sleep, and have made their way to water in order to spawn, or produce their eggs, from which will come the next generation of frogs.

When the winter came the frogs buried themselves in the mud at the bottom of the ponds and ditches, and there they remained in a state of torpor till the spring. No matter how cold the winter is the frogs can generally survive, for they are what is known as cold-blooded animals, that is, their temperature varies very little from that of their surroundings, whereas birds and mammals, including ourselves, generally maintain a constant temperature. The warmth of our blood varies very little between summer and winter.

The Noisy Male

When these awakened frogs have made their way to the ponds and ditches they pair, with much croaking by both sexes. The male makes much more noise than the female, for he has a pair of sacs which he inflates with air, and these then act as resonators. The female lays her eggs or spawn, and these soon float to the surface of the pond as a gelatinous transparent mass. There are anything from one to two thousand eggs each enclosed in the jelly-like substance, and the parent frogs, after spawning, leave the water and the eggs and take up once again their life on land.

The jelly that circles the eggs serves several very useful purposes. In the first place it acts as a float, then, being slippery, it is a good protection against birds and fishes and the larvae of insects which would like to make a meal of the frog's eggs. Finally, the jelly acts as a lens, intensifying the sun's rays and warming the eggs.

When the eggs were first laid each consisted of a black and a white part; the white part, which is always below, contains a store of food on which the little tadpole, as it develops, lives, until it acquires a mouth and can feed in the usual way. Very soon in the middle of the black or upper part of the egg a little pit appears, which develops into a groove, finally reaching right round the egg. Then another groove forms at right angles, and a third groove develops round the egg like an equator. In this way the egg is divided up into eight parts, but it does not stop there. Other divisions appear, until when seen through a microscope it looks something like a golf ball.

The edible frog which is regarded as a great delicacy in France. It is a different species from the common frog of England

After a time the egg ceases to be round, and one sees what is evidently the head and trunk of the future tadpole. Then a tail develops, making the animal look something like a fish, and the tadpole then makes its way out of the jelly covering, and is hatched. This is about a fortnight after the time the eggs were first laid by the mother frog.

But the tadpole as yet has no mouth, and so it continues to live on the food that was in the egg. It is unable to swim properly, and it attaches itself with others of its kind, by means of a sucker on the underside of its head, to the leaves of waterweed. If we examine the young tadpole we shall see fine thread-like growths on each side of the neck. They are external gills, and as the tadpole is exclusively a water creature at this stage it needs gills in order to breathe. The mouth soon appears, and the tadpole now begins to feed on the plants and also to swim about. Soon slits open in the sides of the tadpole's neck, and a number of folds are formed. These are internal gills, and now as the external gills are no longer needed they shrivel up and disappear. The tadpole takes in water through its mouth and passes this out through the slits, and as it goes over the folds the oxygen of the air contained in the water is extracted.

The tadpole now grows rapidly. Its tail has developed, and enables it to swim quickly through the water. At this stage it is much more like a fish than a frog, and for this reason scientists believe that frogs have descended from fish-like ancestors.

Another Change

Now another remarkable change takes place in the tadpole. The internal gills are gradually replaced by lungs, and soon the tadpole is seen to come frequently to the surface of the water in order to breathe air. Gradually limbs appear, first the forelegs and then the hind legs. The tadpole still has a tail, but it is changing into a frog. For a little time it is unable to take outside food, and it absorbs the substance of its tail, which gets less and less. Meanwhile the legs develop, and at last we have a real frog. The gills have shrivelled up, the slits have closed, and the animal leaves the water able to breathe the air of the atmosphere.

It now moves by long leaps, its long hind legs enabling it to travel in this

way Its food consists of insects, snails and worms, and when it wants to eat the frog squats with the fore part of its body raised on its front legs, facing its intended prey Its throat is seen to move rapidly, and the moment an insect begins to move the frog flaps out its tongue like lightning, seizes the insect and draws it into its mouth

The tongue is a queer organ and, as can be seen in the picture on page 1382, it is particularly adapted for catching insects in this way, for it is fastened to the mouth in front, while the back part is free This enables it to be thrust forward with lightning-like rapidity. The mouth also can be opened very wide, the gape extending literally from ear to ear

Once the tongue has managed to bring the insect into the frog's mouth there is no escape, for the frog closes its mouth and its teeth, of which there are two sets, keep the insect in. The insect is soon swallowed. Here it should be mentioned that the frog is a very useful creature and a great friend of the gardener and the farmer, for it devours large numbers of harmful insects.

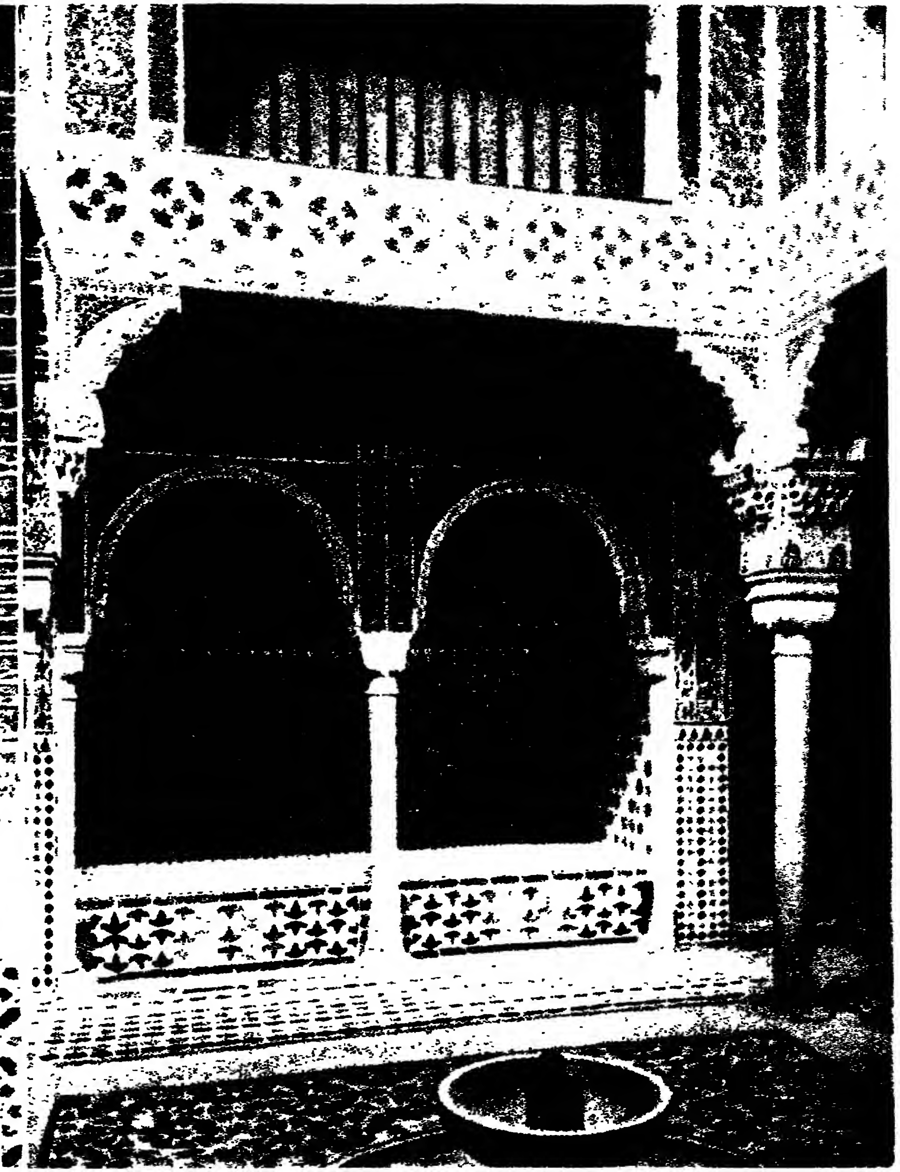
The frog breathes not only through its mouth, but also through its skin, which is very thin, and on its inner surface has many blood vessels. The oxygen can thus be easily absorbed by the blood. All over the frog's skin there is a slimy liquid produced by tiny glands, and this substance helps the skin in breathing, while its evaporation in the warm air keeps the frog's body cool

The frog varies in colour a good deal, having the power of camouflaging itself by making its colour more or less match its surroundings. In the skin of the frog there are tiny specks of brown matter, and these increase in size when the frog is on a dark background and contract when it is amid light surroundings The frog has a number of enemies, among them being the grass-snake which finds this amphibian a dainty morsel.

It is a wonderful round of life that the frog goes through, and yet how unromantic the creature seems when it hops across the grass or when it is heard croaking in the pond! We little realise the romance that is found in the humblest creatures till we study their life-story.

WHY WE SO OFTEN SCREW UP OUR EYES

We often screw up our eyes when looking at things, and there is more than one reason why we do so. If we are looking up at the sky, as these children are doing, or towards a bright light, we screw up our eyes so as to shut off some of the light from entering the iris. The iris itself closes a good deal as in the case of the cat seen on page 90, but even then if the light is very bright, too much of it may enter the eye, and we bring the lids together to shut out still more. Some children, and grown-up people who are short-sighted, close their eyes in order to see better. This has a slight effect in bending the rays of light as they enter the iris, causing them to focus better on the retina. People who habitually screw up the eyes when looking at things are almost certainly short-sighted, and should wear spectacles. In normal circumstances we should, of course, have no inclination to screw up the eyes

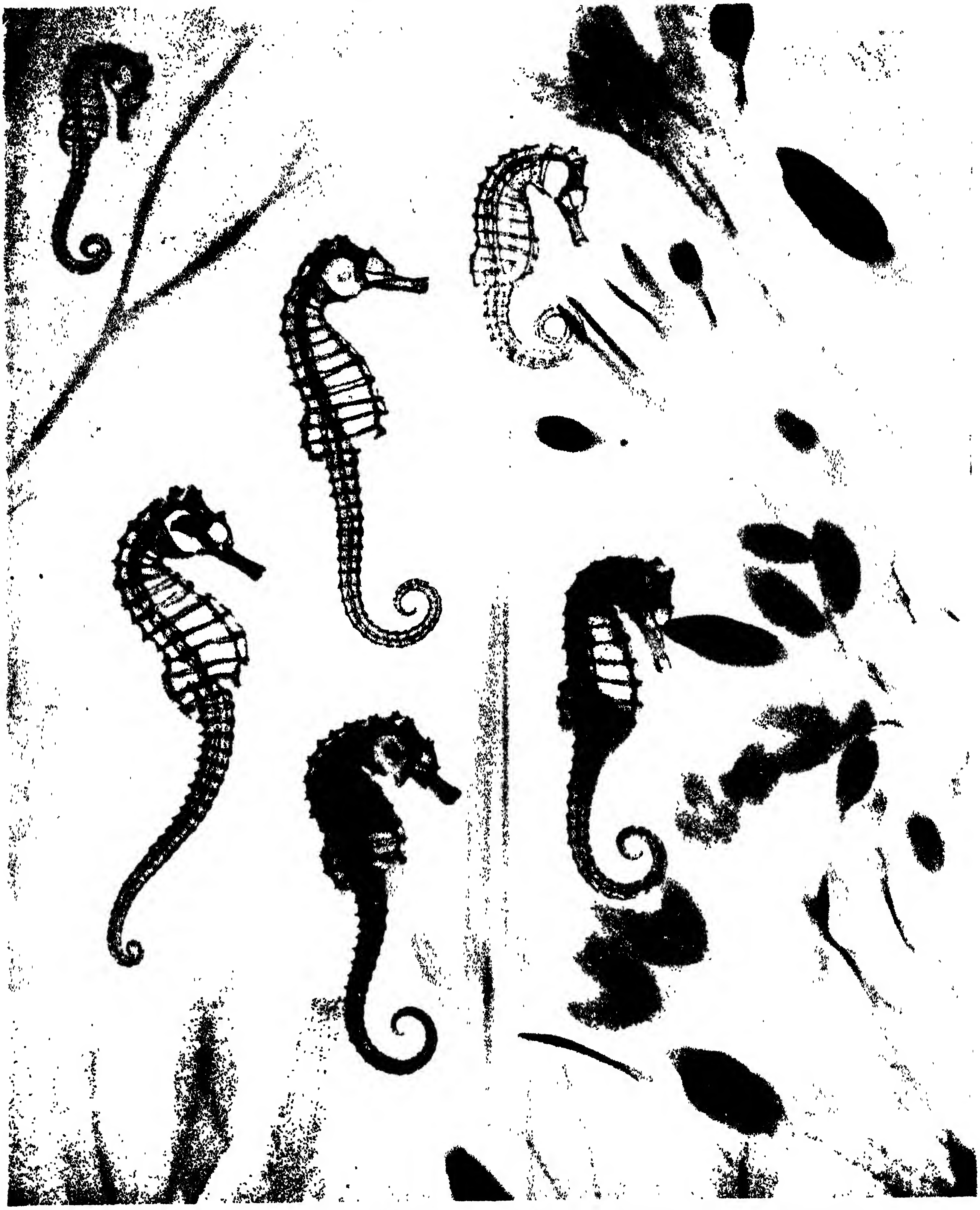


A MASTERPIECE OF ARCHITECTURE ERECTED BY THE MOORS 600 YEARS AGO

In the beautifully decorated, airy, and sunny palace of the Alhambra, built by the sovereigns of the Moorish kingdom of Granada, Spain, in the 14th century, are the typical room and arched windows shown above. Through the ornate window (left) is seen the Captive's Tower, where one of the last Moorish kings kept his favourite Spanish slave. The anteroom to the baths (right) has two deep recesses for couches and, above them, a gallery for singers.

To face page 1385

AN X-RAY PHOTOGRAPH OF THE LITTLE SEA-HORSE



The little sea-horse, found from the Atlantic to Australia, is surely the strangest of all fish, for it looks more like a reptile or a mammal. Nevertheless, it is really a fish. It swims upright and has a flexible tail by which it clings to the stems of seaweed and coral. Sea-horses also link their tails together arm-in-arm fashion. The male has a pouch in which the eggs laid by the female are placed till they hatch out. This photograph was taken by X-rays. In the two lower fish the organs are showing. The two larger specimens above are partially dried, and show little but the bony framework, while the two top ones are completely dried specimens. There are about a score of species of sea-horse and some of these in Australian waters are remarkably like the seaweed among which they live

HOW THE HUMAN ENGINE IS KEPT WORKING

A WELL-KNOWN doctor once wrote a book which he called "The Human Engine," and it is perfectly true that our bodies and the bodies of all animals may be compared with engines. The dictionary describes an engine as a device consisting of several parts which combine to produce a particular effect or do certain work. It is exactly the same with our bodies

As we know, the human body consists of very many parts all beautifully put together in such a way that when the engine is set in motion it can do a great variety of work. It can turn a wheel, pull or push a cart, lift something up, throw an object to a distance, chop down a tree, or saw a plank in two; but it can do what the metal engine or machine can never do, it can think and plan. Whichever of these operations the body is set to do, it can only do it when it is properly supplied, like the locomotive or marine engine, with fuel and water, and these when supplied to the animal engine are called food.

When you buy food as these people are doing from a self-service cafeteria, you are really buying fuel. When you eat, you are supplying fuel to your body, which turns the food into the energy that enables you to work and play. It is very much the same thing as stoking coal under the boiler of a locomotive to turn water into the steam energy that drives the engine's wheels.

Need for Food

Why do we have to take food so regularly? Well, there are two reasons, one is to give our bodies heat and energy so that they can work and the other is to repair the parts of the body which get worn out in the course of the regular working.

It is in this latter way that an animal engine differs from an ordinary engine made of metal. When that wears out so that parts need renewing, we have to make these parts and put them in from outside to replace the old ones. In the animal engine, however, that is in our bodies and those of all other animals, the parts are repaired by the engine itself as it goes on working.

This is really very wonderful indeed A child is born very small, but directly it comes into the world it begins working, that is, it moves its arms and legs and other parts of the body, and as it does so it uses up some of the tissue of which the body is made. That must be constantly renewed if the child is to live, and so immediately after it is born it has to be fed, and it has to go on feeding till the end of its days. If it were to stop taking food for any length of time, it would first of all cease working, and then it would die. Food includes water

A child's body needs a great deal of food because, unlike that of a full-grown man or woman, it has not only to renew what is worn out through the working of the body, but it has constantly to add to the various parts so that they may get bigger and bigger till the child has become a full-grown man or woman.

Now there are two kinds of food which our bodies have to take if we are to grow and do our work. One kind consists of flesh-like substances, animal and vegetable, which are known as proteins. They contain the chemical elements carbon, hydrogen, nitrogen, oxygen, sulphur, and sometimes phosphorus, these being the principal substances of which our bodies are composed. We can understand, therefore, how important it is that we should take sufficient of these proteins to provide new tissue for various parts of our body.

Primary Food

The word protein comes from a Greek word meaning primary, and the name is given because the proteins contain the primary substances of which all bodies are composed Inside the body they are changed into protoplasm, a half-transparent colourless substance which is the basis of animal and plant life.

Proteins are the only foods from which our bodies can take nitrogen, and without sufficient proteins we die.

The other class of food which we need consists of combustible substances known as carbo-hydrates and fats. The carbo-hydrates are so called because they consist of the elements carbon, hydrogen and oxygen, and though they cannot be changed into protoplasm they can be oxidised or burned quite easily, and thus supply the energy we need. Starch and sugar are two forms of carbo-hydrates.

The fats, which are also fuel foods, contain the same elements as the carbo-hydrates, but because they are more complex in their composition they are more difficult to digest. They are of various kinds, as in butter, the fat of meat, the cream of milk, and the oil

The more exercise you take, the more energy you use up, therefore the greater need of food to replenish the fuel supplies of the body. The energy-giving foods are rich in fats and carbo-hydrates, some more so than others. The table in page 711 lists the chief energy and health-giving foods.

contained in seeds and kernels. They contain more carbon than carbo-hydrates, and in consequence give more heat and energy. For example, an ounce of beef fat or butter has 2¼ times the fuel value of an ounce of sugar or starch. They are more concentrated fuels than the carbo-hydrates.

But just as the railway engine needs coal to burn and provide the heat, so it also needs large quantities of water, and our bodies are similar in that respect, for they, too, need a constant supply of water. More than half the material in our bodies consists of water, and though men can sometimes live for many days without other food, they cannot go very long without water.

The water need not, of course, be taken as plain water from the tap. It is the chief substance in milk, tea, coffee, and other beverages, and is also present in large quantities in fruits, vegetables, and other solid foods, but it is always good to drink plenty of water.

Water is really a mineral food, and there are one or two other minerals which we need to take into our bodies. The chief of these is common salt, and others are phosphates, chlorides, carbonates of sodium, potassium and calcium, and some of the salts of iron. They are present in small quantities in most of our foods, and they help to supply the body with minute quantities of elements like calcium, iron, potassium, and iodine, which are needed for health. When a body is cremated the water evaporates, carbon and most of the other substances are burned up and disappear, but there are always a few ashes left and these are the minerals in our bodies.

The foods which we eat pass inside our body and are there acted upon by the various juices and are burned up just as the coal is burned up in the railway engine furnace, and some of the heat produced by the fuel, whether it be in the locomotive, or our bodies, remains as heat while another part is changed into mechanical energy. It is the energy set free by the burning of the organic substances in our body that gives the power to perform all the various actions we do, whether it be running, walking, sewing, dancing, or thinking. The heat which remains heat warms the blood and is carried to all parts of the body, maintaining them at almost the same temperature, namely 98½ degrees Fah. The heated blood keeps the body warm just as the hot-water pipes keep a house warm.

When we take vigorous exercise the rate of burning in the body is increased, and then by a wonderful arrangement more blood is supplied to the skin and the extra heat there increases perspiration. When a liquid evaporates it takes up heat and so by this ingenious arrangement the perspiration carries off the surplus heat and our bodies are cooled down to the correct temperature which is best for health

FIERCE EAGLES THAT LIVE UPON MONKEYS

We know that the eagle is the fiercest of birds, and that even in Great Britain the golden eagle will prey upon young lambs and carry them off from their mothers to the aerie, where they provide a meal for the young eagles. Stories have even been told of children being carried off by eagles, but these are only stories. An eagle is strong and powerful, but it is probably not strong enough to carry off a child.

There are, however, eagles which prey upon monkeys; and one species, known as the monkey-eating eagle, which lives in the forests of the Philippine Islands, is said to live almost entirely on the macaque monkeys which are found in the Philippines. This creature has a large head, with a powerful beak not unlike that of a cockatoo. There is a crest of feathers on top of the head, and this gives the monkey-eating eagle a formidable appearance when it is angry or attacks its prey. The claws also, like those of other eagles, are exceedingly strong.

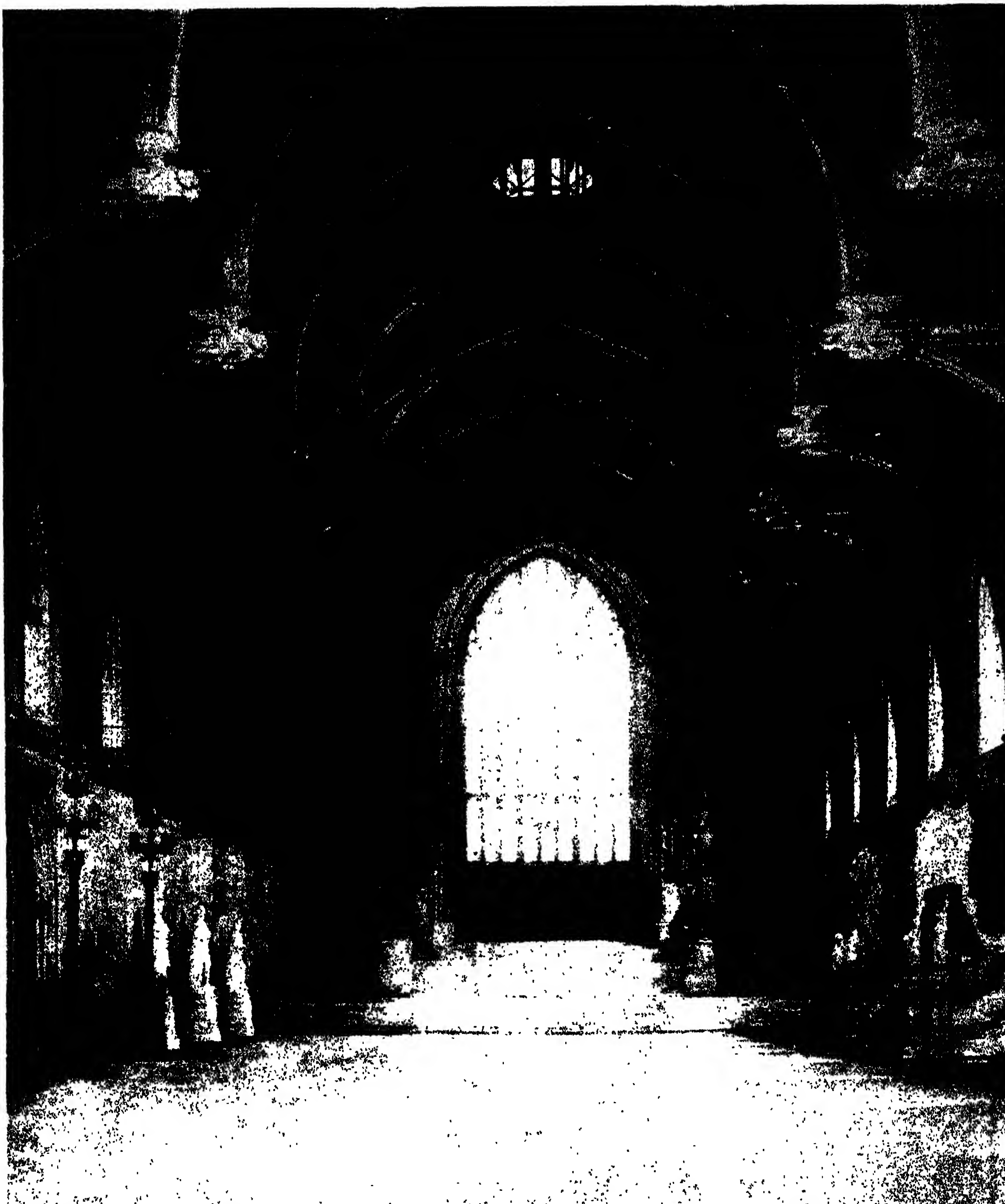
This eagle is the terror of the air to the monkeys that live in the Philippine Islands, for it lives upon them, catching them with its terrible claws and rending them with its powerful beak. It is called the monkey-eating eagle

This bird spends its time high up in the forest trees, and pounces down upon the poor monkeys whenever it needs food In districts inhabited by human beings, however, the eagle is not so particular, and it finds it easier to swoop down on the farmer's poultry yard and seize one of his fowls or ducks. This it takes off to its home in the trees and there eats its meal in comfort.

This monkey-eating eagle, however, is not the only one of its family which finds monkeys a suitable meal. The harpy eagle, which is found in South and Central America, also catches and eats monkeys, though it does not confine itself to this fare so exclusively as does its relative of the Philippines. It sits for hours almost without movement on the top of some dead tree giving a loud cry every now and then. It will kill animals three times its own size, and monkeys often fall a victim to its talons and beak.

In the early morning it flies up in the air wheeling in circles round the forests, thus taking exercise and at the same time looking out with a keen eye for likely prey. Peccaries, sloths and turkeys also form welcome food for the harpy eagle.

A ROOM WITH 75 TONS OF AIR INSIDE IT



Except when the wind blows strongly we never feel the pressure of the atmosphere, yet, as we know from the fact that a 30-inch column of mercury is pressed up in the glass tube of the barometer, the air has a very definite weight. On every square inch of our bodies the atmosphere is pressing with a weight equal to 14·7 pounds, and 13 cubic feet of air weigh one pound. Perhaps the room we are sitting in is 10 feet high, 12 feet long and 12 feet wide. Then the air contained in it weighs about a hundredweight. Think of the weight of air in a bigger apartment, like Westminster Hall, shown in this photograph. The Hall is 290 feet long, 68 feet wide, and 110 feet high, so that its volume is 2,169,200 cubic feet. The weight of the air inside it at any time is therefore about 75 tons. How incredible this seems, and how still more staggering is the fact that the Earth's atmosphere weighs at least 5,178 million million tons—that is, nearly one 1,200,000th of the Earth's mass. Of course some gases like carbon-dioxide are still heavier than air

THE SIREN THAT WARNS THE SHIP IN FOG

Almost everything in the modern world is produced on a bigger scale than was possible in the olden times or even a hundred years ago. This is as true of noise-making instruments as of other things and though it is often true that loud noises like motor horns in city streets or country roads are a pest, sometimes, as described here, piercing sounds are of untold value and do much good

MANY a good ship has been saved from the disaster of collision with another ship or from being driven upon a rock by the warning note of a siren or foghorn which sends out its piercing note far over the waves and rising high above the sound of the gale.

This apparatus was invented by a French physician, Cagniard Latour, in the early years of the nineteenth century, and he himself gave to it the appropriate name of siren, because its voice is heard by the mariner, just as were the voices of the sirens of classical legend. The difference, however, is that whereas the ancient sirens lured seamen to their doom, the modern siren warns them of lurking danger and enables them to escape the peril.

In principle the sirens of to-day are like the simpler device first made by its inventor, but, of course, they are so extraordinarily powerful as to make an early siren seem almost like a toy whistle.

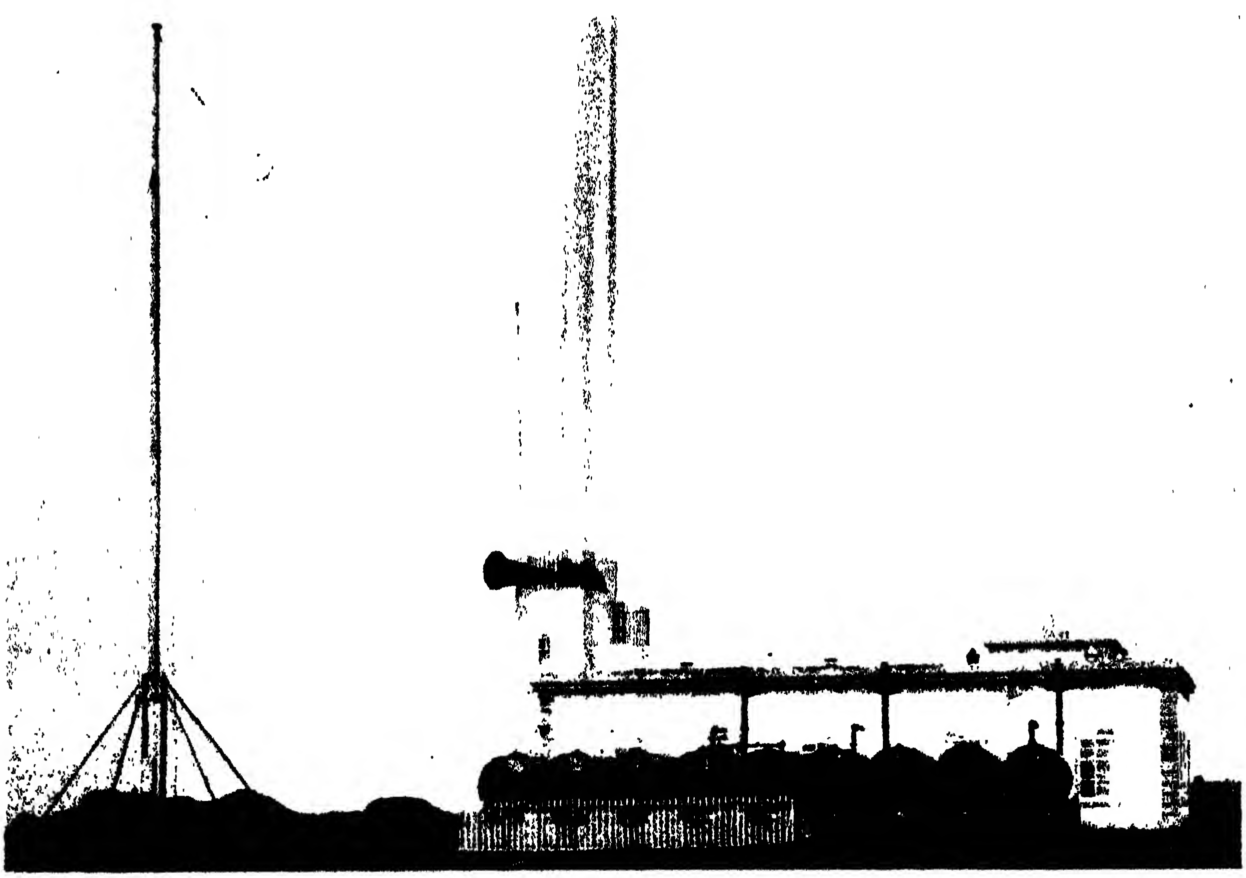
The sound-making device of the siren consists of a revolving disc or cylinder moving over another and both pierced with a number of holes, which during rotation periodically coincide so that the upper holes come over the lower ones.

Compressed air or steam is blown with great force through the holes when the lower ones coincide with the upper ones, and this sets the air in rapid vibration. The result is a loud and shrill sound which is concentrated and sent in the required direction by means of a big horn, as shown in the photograph on this page.

The moving parts of the siren or foghorn are sometimes worked by an electric motor and sometimes driven by the steam or compressed air as it passes through the holes. When the latter is the case the holes are not pierced at right angles to the surface of the discs but slantingly, so that the air or steam will give a thrust as it rushes through.

Then, again, the horn can be made to sound either by the pulling of a hand lever or by some automatic device which sends out the piercing note at regular intervals.

Enormous improvements have been made in the construction of sirens during recent years, and some of the powerful foghorns erected to-day at lighthouses round the coast can send out a note that in a favourable atmosphere will carry for twenty miles or more. Of course, much depends on the state of the atmosphere, but the weather is generally more or less calm in foggy weather and therefore favourable to the carrying of sound over long distances.



The foghorns with the compressed air cylinders that work them at the Cumbrae Lighthouse on Little Cumbrae island in the Firth of Clyde. These are the loudest foghorns in the world, and are used in connection with a talking apparatus and wireless for warning ships, as described on page 394, where the principle of the new style of lighthouse is explained

THE STRANGE BEHAVIOUR OF A LIGHT RAY

We sometimes read or hear about light that has been polarised. What exactly does this term mean and in what way does polarised light differ from ordinary light? Further, what is the practical use of polarised light?

Well we know that rays of light pass through air or ordinary glass or water unchanged, although, of course, the rays will be bent in passing from one of these substances into another, as shown on page 222.

There are certain substances, however, which have a curious effect on light when it passes through them. One of these substances is Iceland spar or crystal of calcite, and as we see on page 222 if a sheet of printed paper be viewed through it, the print will appear doubled. This is because a ray of light passing through the crystal is split so that it takes two paths.

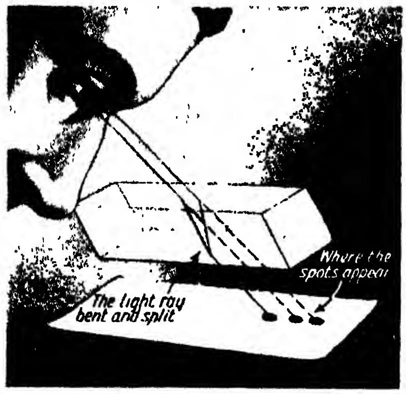
In one case the light passes through in the same way as it would through glass or water, and it does not matter in what position we place the crystal over the print. This is called "the ordinary ray." But the other part of the split ray of light is called "the extraordinary ray," and this behaves quite differently.

If we move the crystal round on top of the paper, we shall find that the second image of the print moves round the first image, while that first image, all through the movement, remains stationary. When we find these curious results the light is said to be polarised.

Calcite or Iceland spar is not the only substance that affects light rays in this way. All crystals except those which form as cubes or belong to the cubic system do so, though in varying degrees; animal substances like horn and shells do the same, also some vegetable substances like resins and gums; and certain artificial substances such as jellies and annealed glass, or glass that has been toughened by being heated and slowly cooled.

Now why does a ray of light behave in such a curious way when passing through any of these substances? It has to do with the arrangement of the molecules in the substance. Suppose a flat fish like a plaice that swims in the water horizontally were to come up against a net with meshes that ran up and down. The fish would be stopped and unable to get through the net unless it could turn on its side.

Well, light is something like that. The waves of light are at right angles to the



How a light ray is split or polarised by a crystal of calcite so that an object seen through the crystal is doubled

direction in which they are travelling, but this does not matter when they are travelling through substances like air and water. When, however, they are travelling through a crystal of calcite, and are split into ordinary and extraordinary rays, the extraordinary rays pass as it were through the meshes of a net, the openings of which are in the same direction as the waves. If a second calcite crystal be now placed in front of the other, but at right angles to it, the extraordinary rays are stopped by it.

Let us illustrate this by an experiment. Tie a rope to a post and between the post and the end in our hand let there be a fence of upright posts. When we give the rope a wavy motion up and down the waves pass from our hand through the fence to the post. Now let us put a second row of upright posts between the first fence and the post to which the rope is tied. Still the waves given to the rope pass through. But if instead of upright posts in the second set we place horizontal bars, the waves will after passing through the first fence be stopped by the second one.

It is like this with the polarised light. The extraordinary ray passed through the first crystal because the grating of molecules as it were is in the right direction for the waves, but in the second crystal which has been placed round the other way the grating is across the waves and so they are stopped.

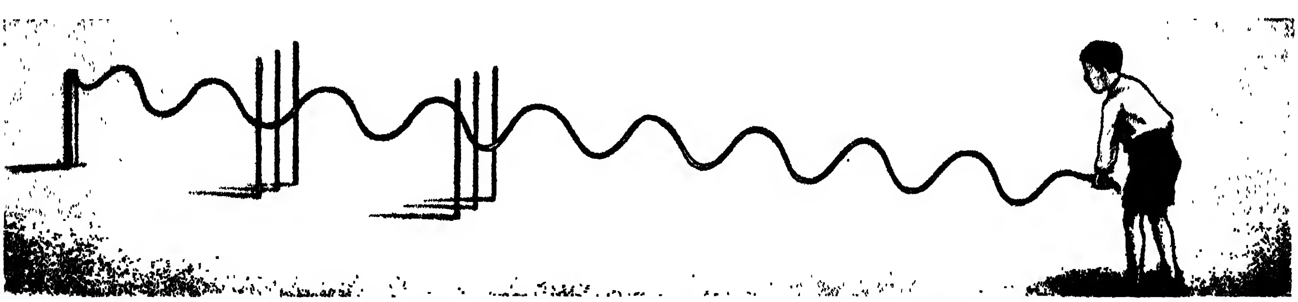
This curious property of polarised light is of great use in testing certain substances. For example, a sugar solution polarises light more or less according to the amount of sugar in the solution, and so an instrument called a polarimeter or polariscope is used to see how near the sugar solution is to crystallisation.

The method of making this test is quite simple. The crystal used for polarising the light is tourmaline. At one end of the instrument a plate of tourmaline is arranged in a certain direction, and at the opposite end a plate is placed at right angles to the direction of the other. The first plate is called a polariser, and the second an analyser.

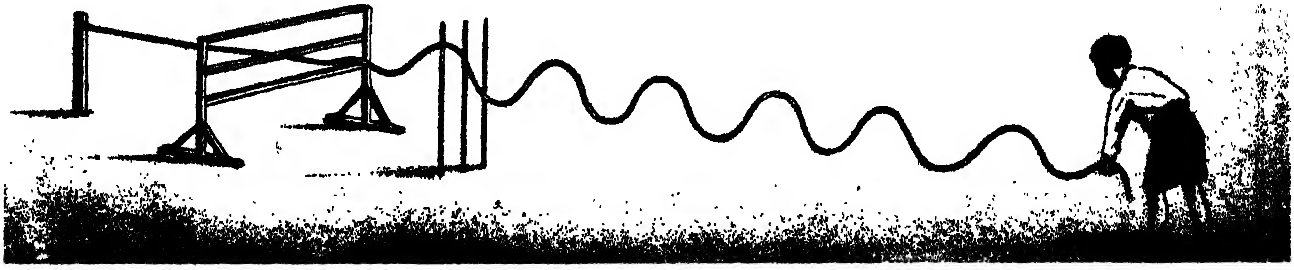
The substance to be examined is placed between the two tourmaline plates. For liquid substances like the sugar solution the polarimeter is in the form of a tube with the crystals one at each end.

For the examination of solid substances by means of polarised light the instrument is two flat discs with the crystal plates in the centres, and the substance to be examined is placed between these.

Light can be polarised not only by refraction but also by reflection, a fact that was discovered by a French scientist while examining the light reflected from the windows of the Luxembourg Palace in Paris, with a piece of Iceland spar.

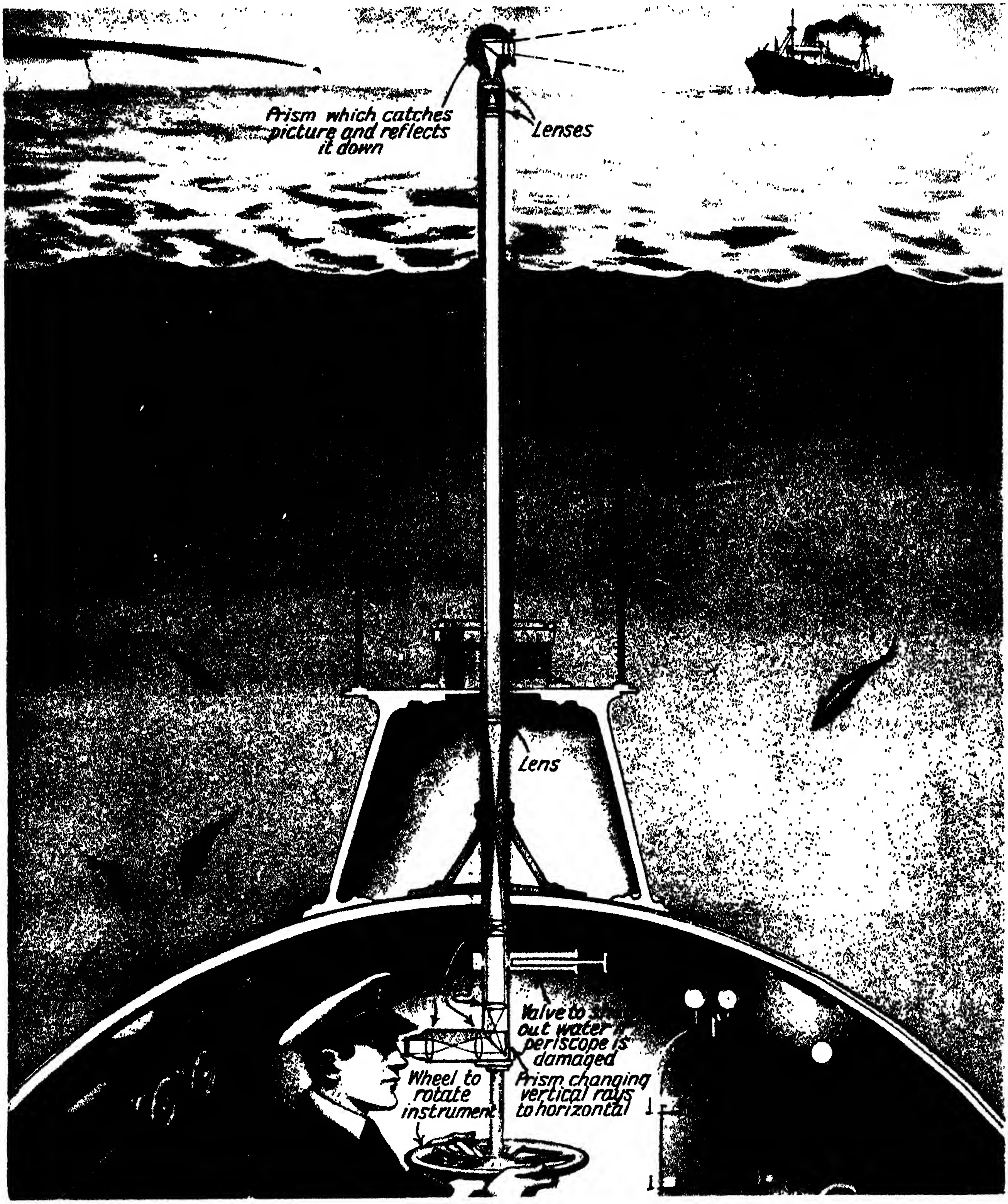


The waves as the rope is shaken are able to pass unhindered through the upright posts



The waves as the rope is shaken pass through the upright posts unhindered, but are stopped by the horizontal bars

WHAT THE EYE OF THE SUBMARINE IS LIKE



In this picture diagram we see how the periscope of the submarine enables the officer in charge to see what is going on at the surface of the water and round about. The principle of the periscope is shown in simple form on page 1200, but we can see in this picture that the actual periscope of a submarine is much more elaborate. Its top is of small diameter, so that it shall not be very visible. The disadvantage of this is obvious, for the picture obtained by it is very small. Further, in order that the officer may obtain a good view of what is going on at the surface, the rays of light have to be changed in direction more than once. The picture is caught by a prism at the top of the tube, and is reflected down through a number of lenses to another prism at the bottom, by which it is directed at right angles through a kind of telescope. In this are additional magnifying lenses, and when the officer looks through the eyepiece he sees an enlarged picture. The periscope illustrated has been greatly simplified and the various parts have not been drawn to scale.

A LONELY SURVIVOR FROM A REMOTE AGE

This great mass of rock, which stands in the State of Oregon, U.S.A., is a strange survivor from a remote age. It consists of hard rock which, when rain and river were at work eating away the Earth's crust, in this part of the world was able to resist these disintegrating agents. The rock all round was softer and so succumbed to the erosion, leaving this pillar like a huge peg-top poised upon its point. It is known as the Martha Washington Rock, and is a notable landmark for many miles round. Of course, in a case of this kind, after the rocky pillar has been isolated by the action of water, the wind continues the erosion, though more slowly

HOW ROCK PILLARS ARE LEFT STANDING

The surface of the Earth's crust is everywhere changing its form, for it is being constantly sculptured by a variety of agents like sea, river, rain and wind. The form of the sculptured rock, as we read here, depends largely upon its nature and position, that is, whether it is hard or soft, stratified or igneous, horizontal or inclined

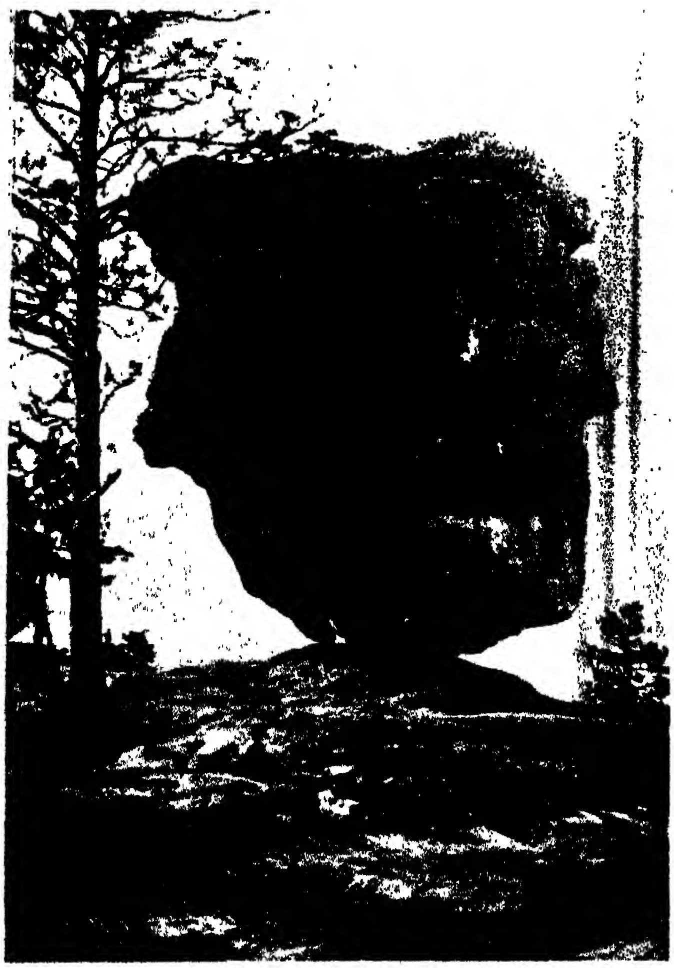
Some great rock boulders may be seen nicely balanced on a base, a position in which they have remained for ages. But they were not always there, for they have been carried to their present place by a river or glacier that flowed over the region in a past geological period and were left in their strange position with the centre of gravity so nicely poised that nothing but a big thrust would send them from their perch

There are other rocks, however, standing like monuments which have always been in the place where they are now. Examples are given here and others will be found in other parts of this book

These have been left standing owing to the washing or wearing away of softer rocks that once surrounded them Sometimes the sculpturing has been done by the sea, though the rock may, owing to ancient upheavals, be now standing far from the ocean. In other instances the denudation may be the work of river, rain and wind.

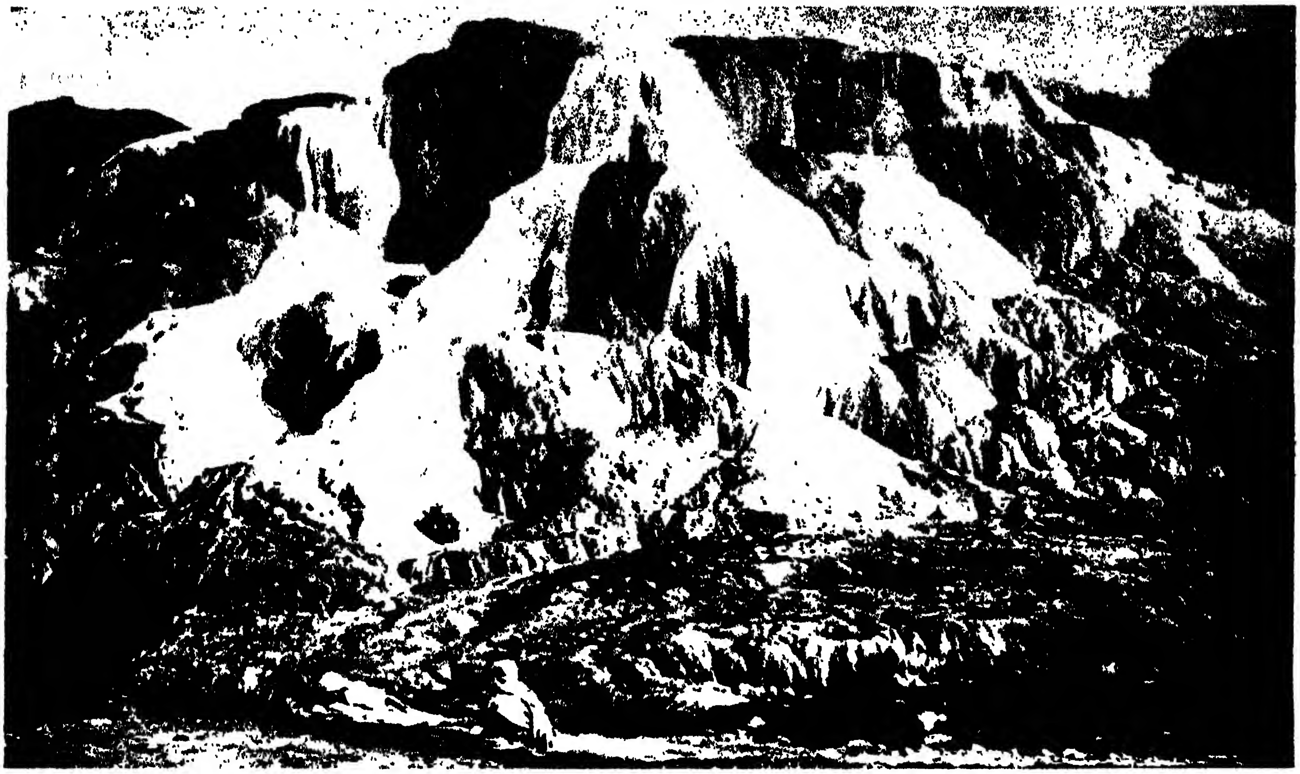
Rock-weathering is always best studied in river ravines, along the sea coast or among the mountains. Generally the worn rocks do not stand as isolated monuments, because they are concealed under their own ruins, that is they become more or less buried by the fragments broken off from their mass. In place of the perpendicular face of rock there is a slope made up of the debris that has been worn off the bed-rock.

The shape of the weathered rock depends, of course, very largely upon its nature. Each rock-type breaks up and weathers in its own way, and the resulting forms depend also upon whether the strata were horizontal or by some upheaval had been thrown into an inclined position. Stratified rocks, like limestone and sandstone generally break up into angular forms, whereas basalt weathers rapidly into rounded forms, like the example shown in the photograph on this page.



Here are two remarkable denuded rocks, which are to be seen in America, the land above all others of geological wonders. On the left is a balanced rock, which stands in the Garden of the Gods, in Colorado ; while on the right is a curious toadstool-like rock known as Coalca's Monument, which stands 300 feet above the gorge of the Wilamette River near Portland, Oregon. It consists of basalt, and the Coalca after whom it is named was a Red Indian chief who, according to tradition, was killed at this place.

HOT CASCADES AND NATURAL PAINT GEYSERS

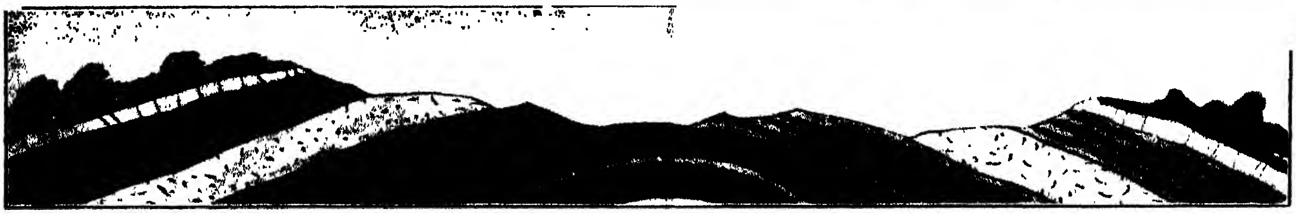


In this photograph we see a remarkable natural phenomenon at Hammam-Meskoutine, in Algeria. Over a series of terraces of hard rock pours a great stream of hot water that wells up from boiling springs far below the ground. The water contains large quantities of sulphate of lime and common salt, and when the water evaporates the sulphate of lime is left in the form of gypsum, a white rock

There is a strange sight to be seen on an island in the Salton Sea of Southern California. Geysers there are continually spouting thick liquids of varied colours from cream to brown, which have been used as an excellent substitute for paint. The exact nature of these strange natural pigments is not known, although geologists have made investigations. Traces of helium gas have also been found at these geysers. The outlets of the geysers are weird-looking hollows or basins three feet or more in diameter, and the paint-like mud is continually bubbling up as the steam escapes. The Salton Sea is an overflow from the Colorado River

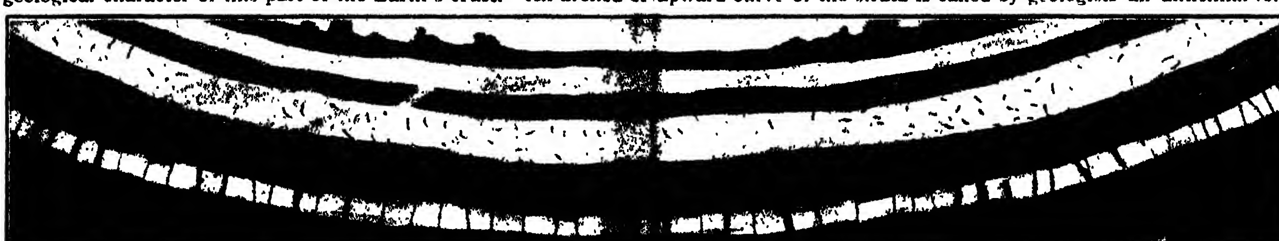
HOW GEOLOGY MAKES THE LANDSCAPE

The scenery of a country is largely made by its geology, as the pictures on this page show. Here we see how the strata of rocks deposited in water through the course of ages and hardened by the pressure on top have been folded or contorted in an upward direction

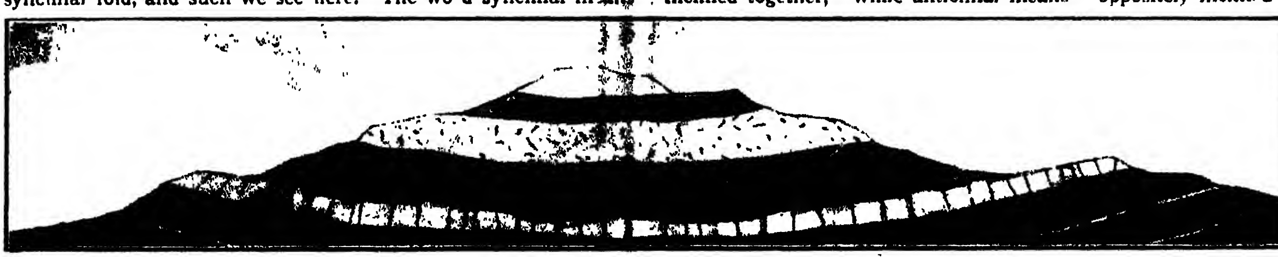


The contortion or bending of the strata was caused by pressure at the sides as the Earth shrank in cooling. As time went by the wind and rain and rivers, and in some places the sea, wore away the upper rocks till the layer of strata became as shown here in section

The landscape of a region where the rocks have been folded in an upward curve, as shown above, and then worn away indicates the geological character of this part of the Earth's crust. An arched or upward curve of the strata is called by geologists an anticlinal fold



When the curve of the strata, owing to pressure at the sides, is downward, so as to form a trough instead of an arch, it is called a synclinal fold, and such we see here. The word synclinal means "inclined together," while anticlinal means "oppositely inclined"



In this picture we see the previous strata in section after the weathering has gone on for ages, and rivers, rain and wind have worn away much of the upper rock. Rivers are, of course, great sculptors of the landscape, as we see in the Colorado Canyon on page 930

This picture shows the kind of landscape we get where the geological formation is a synclinal fold. Both forms of landscape are seen in scores of places in Great Britain and other countries Contorted strata over a large area show both anticlinal and synclinal folds

HOW RAINFALL & SNOWFALL ARE MEASURED

RAIN is one of the most important of weather phenomena, and great care is taken in making measurements of the rainfall at different places. All over the country in thousands of places the rainfall is measured by means of an instrument known as a rain-gauge. Sometimes the rain-gauge is placed in the middle of a field or lawn, but in towns it is usually kept on the roof like the one shown in the photograph.

The rain-gauge has various forms, but they are all the same in essence. There is a vessel for catching the rain as it falls and a measuring rod for determining its depth. Such instruments for measuring the rainfall have been in use for at least 300 years.

Catching the Drops

It is important that the rain when it has fallen should not be able to evaporate, and generally the receptacle for holding the rain is in the form of a bottle, and has a funnel which catches the drops and enables them to run into the bottle, the narrow neck of the bottle preventing evaporation.

Generally the bottle and funnel are stood in a galvanised iron cylinder. Sometimes the cylinder is of copper, as is also the funnel. While the top of the funnel is five or six inches in diameter, the opening allowing the water to flow into the bottle or other receptacle is narrow.

At the top of the funnel there is a vertical rim about six inches in depth, the inner surface of which fits over the metal cylinder. Its object is to prevent splashing as the raindrops fall. It is important that the mouth of the funnel should not be dented, otherwise it will not collect the full amount of rain.

Generally the amount of water in the gauge is measured by means of a measuring rod, though sometimes the water is poured out into a measuring glass with fractions of an inch or metre marked upon it.

There are more elaborate rain-gauges which automatically record the amount of rainfall on a chart, indicating the duration as well as the amount of rainfall during a given period. How these gauges work can be seen in the explanatory pictures on page 548.


A rain-gauge on a roof in the City of London

For mountain regions where a good deal of rain falls but the gauge can be visited only at rare intervals, there is a slightly different form of apparatus, with a funnel and vessel much deeper than usual.

The situation of the rain-gauge is very important. The best position is said to be an exposed site in the open from three to six feet above the ground. This, however, is often difficult to get in towns. Rain-gauges should be a considerable distance from trees, buildings or other obstructions that might cause eddies of wind, as such eddies affect the total amount of fall considerably. The higher up a rain gauge is the greater generally is the speed of the wind, and hence the loss of rain is also greater.

In the case of snowfall, two measurements are taken. One is the actual depth of snow as determined by a measuring rod, in places where there has been no drifting. Usually three or four places are measured and the average taken. The other is to melt down the snow collected in a rain gauge, from which the funnel and inner cylinder or bottle have been removed, and then to measure the depth of water.

Taking a Sample

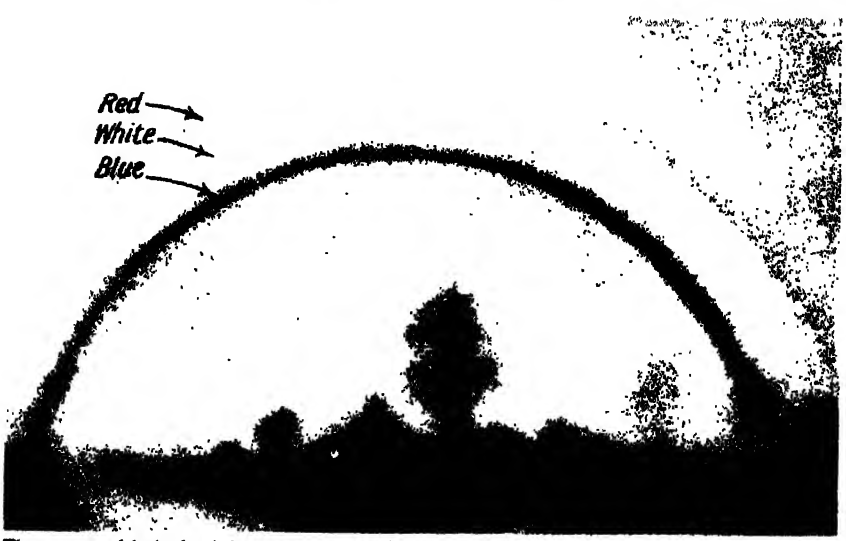
Sometimes where a strong wind has been blowing and it is thought that too much snow has been blown into the rain-gauge, another method is used. A sample is taken by inverting the can and pressing it down in the snow in some place where there has been no drifting. A piece of tin is then passed under the can, which is lifted with the snow in it. This is then melted down.

The number of inches of snowfall corresponding to an inch of water varies between six and thirty inches of snow for one inch of water. It depends upon the lightness of the snow.

THE FOG BOW AND HOW IT IS CAUSED

SOMETIMES, when there is a light fog and the Sun can be seen shining through it, we see opposite the Sun a whitish rainbow, to which the name of "fog bow" is given. It is usually reddish on its outer margin and has a blue tinge on the inner margin. The middle part of the bow, however, is quite white.

The fog bow is produced in exactly the same way as the ordinary rainbow, in which we see the colours of the spectrum.

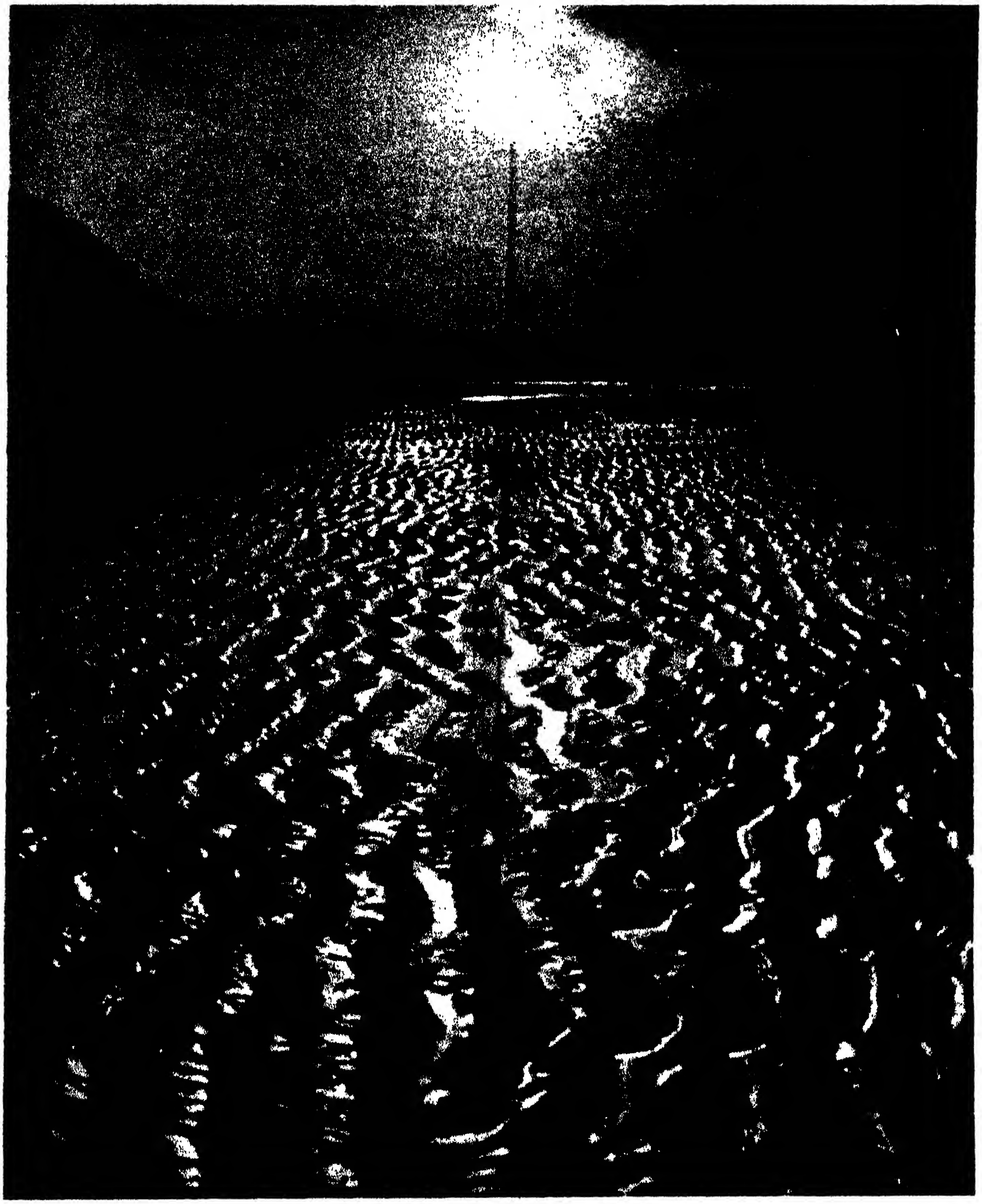


The strange kind of rainbow seen in a light fog and known as a "fog bow." The upper or outer margin is a faint red, while the inner margin is bluish.

That is explained on page 20. The reason for the difference in the two kinds of bow is that when we see a fog bow the drops of water in the atmosphere, which refract and reflect the Sun's rays, are so very small that the colours become mixed before they reach our eyes, and so unite once more to produce white light.

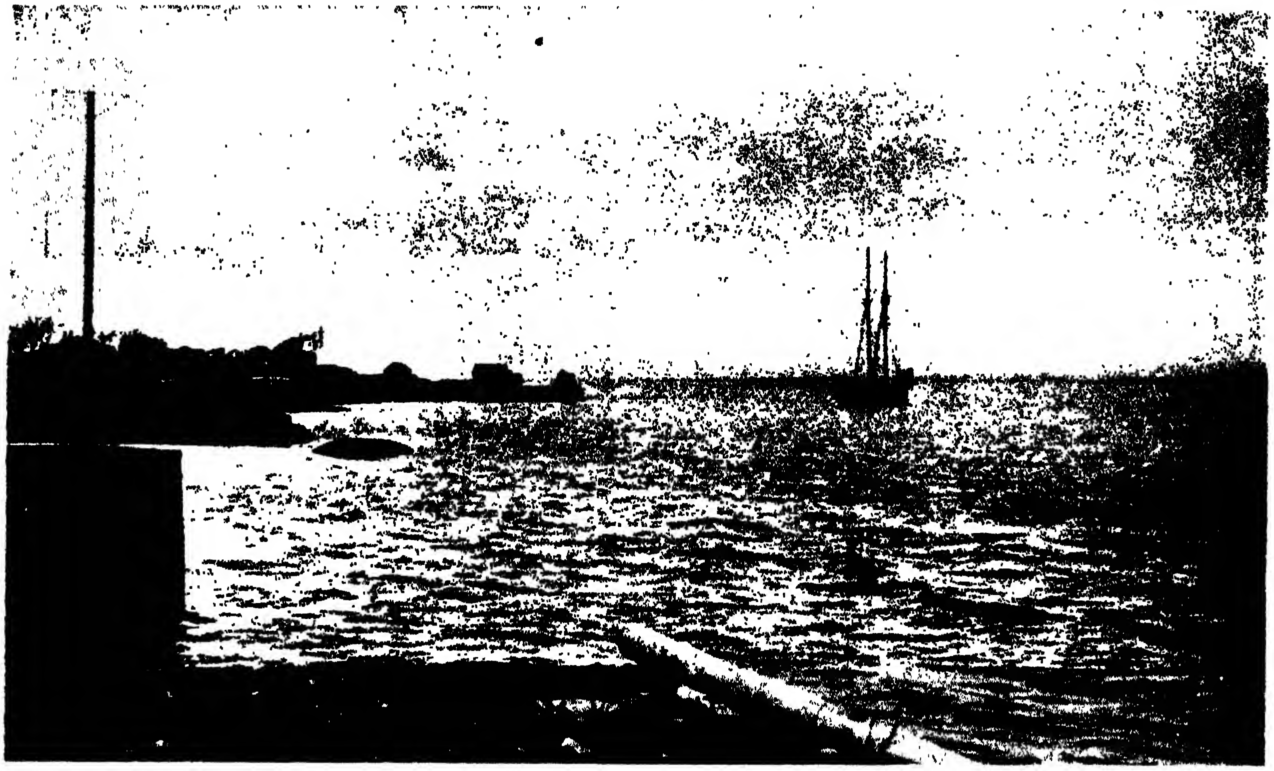
It would take at least a thousand of these drops of moisture, placed side by side, to measure an inch so small are they.

RIPPLE MARKS IN THE SAND MADE BY THE SEA



When the sea covers the beach, as it does at high tide, the movement of the waves causes ripples in the wet sand below, and then when the sea recedes, as at low tide, the sand is exposed with the ripple marks covering its surface. In this photograph we have a striking example of these sand ripples caused by the sea waves at Whitby in Yorkshire. It is interesting to compare these with the sand ripples formed by the wind blowing over the desert shown on page 508. Sand ripples are also caused in the beds of rivers and streams. Of course, the ripple marks we see on the beach are of only temporary duration. When the tide comes in once more the old ripple marks are obliterated and fresh ones made. In certain circumstances, however, the marks can be preserved. Sometimes when sandstone is split open we find the marks made in the sand by the sea millions of years ago, preserved by some inrush which buried them under other sand

HIGH TIDE, LOW TIDE, AND SEA LEVEL



The two photographs on this page of the same place taken from the same position look very different from one another. That is because the upper photograph was taken at high tide and the lower one at low tide. The scene is near Halifax, Nova Scotia, where the difference between high and low tide is over ten feet. The tides occur twice every twenty-four hours, that is the margin of the sea is constantly changing its level, yet we reckon heights from sea-level. What exactly do we mean by this, seeing that there is no constant sea-level

When we speak of sea-level we do not mean the level of high tide, shown in the upper photograph, nor that of low tide, shown here. The sea-level from which heights are reckoned is the mean level between high-water mark and low-water mark. The Ordnance Survey of Great Britain has fixed the sea-level, or "datum-line," as it is called, as the mean tide-level at Liverpool. Some place must be decided upon because sea-levels vary at different spots. "Trinity High-Water Mark" is the level of high water at London Bridge

BRITAIN SHOWS THE BETTER WAY

The world was once given a splendid object lesson to prove that there is a better way than war of settling disputes between nations. Great Britain and the United States, on one occasion in the nineteenth century, when there was a hot controversy between them in which their rights and honour were concerned, agreed, as told here to submit the question to arbitration and to abide loyally by the decision

WAR is almost always a foolish business. Under modern conditions of civilisation neither side can gain by war anything that is of real value. This had been maintained by writers for some time, but the events that have followed the Great War have proved it beyond the shadow of a doubt.

Every nation that took part in that War is worse off to-day. Victors and vanquished alike are suffering, and even the neutral nations which did not take part in the War are also paying the penalty that war imposes.

With war waged on the grand scale with high explosives and all kinds of ingenious devices for destroying life and property, the damage is appalling. Millions of valuable lives are ended, and still more millions of human beings permanently crippled, while in the course of a few hours a whole town or a chain of villages can be wiped out, so that the district where they flourished is no longer recognisable. All this goes on during a war, and then when the peace comes, both those who won and those who lost have to pay the enormous cost.

That there is an infinitely better way was proved conclusively by Great Britain and the United States towards the end of the nineteenth century. There was a matter of dispute between the two nations, and feeling ran high in both countries. It would have been easy for hotheads to have led the two peoples into a long and bitter war, as the result of which both would have been worse off and no satisfaction gained.

Instead, the British and American peoples decided to act like civilised human beings, and to have their dispute decided upon by an impartial tribunal. In other words, the nations acted as sensible individuals act. They took their case to Court, and agreed that when the decision was given they would abide by it loyally

A Beacon for Peace

This remarkable gesture, which showed the whole world the better way to settle international disputes, is not given the place in history books which it should have All boys and girls, and grown up people, too, should know the story of the *Alabama*, which may well be regarded as a beacon on the path to Peace.

When the Civil War broke out in America, the Southern States, which wanted to break away from the North and form a separate independent country, had little shipping or overseas commerce, but the Northern States had many merchant ships on the seas.

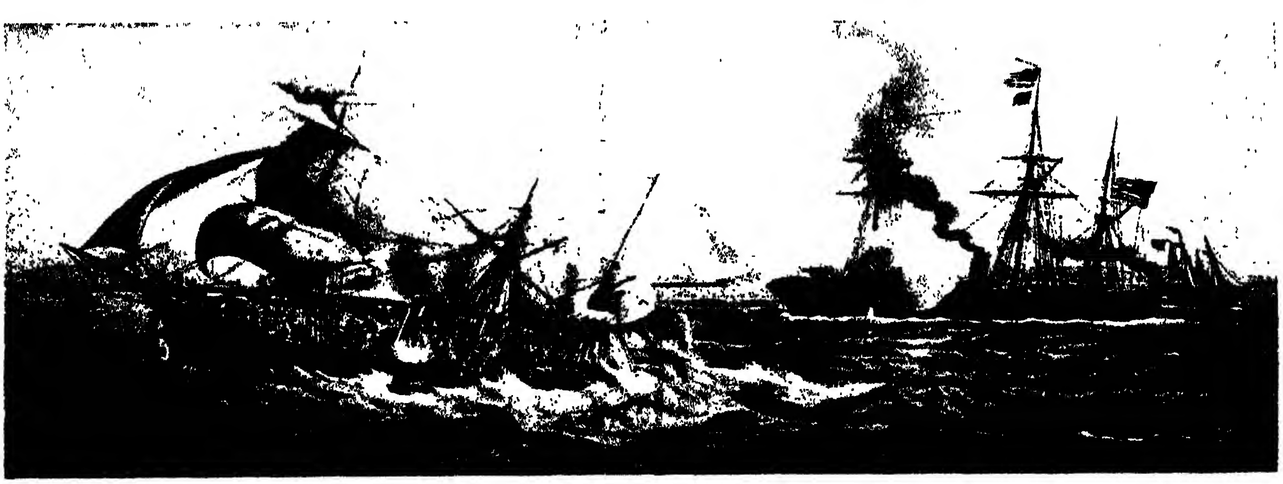
The Southern, or Confederate States, as they were called, decided that it would be a fine thing for their cause if they could fit out a number of vessels as warships, and prey upon the commerce of the North. But where were they to get the ships and the guns and ammunition required ?

They decided to order the ships from English shipyards, and quite a number of vessels were built for this purpose. Of course, when the orders were given and the ships were being built, it was not definitely stated that they were intended to prey upon the commerce of the Northern States of America But it was pretty generally known, and when the American Minister in London learnt about these ships he urged upon the British Government that it was their business, as ministers of a power professing to be neutral, to stop them leaving port.

The most destructive of all these vessels which ploughed the sea in quest of plunder was the *Alabama*. She was a small vessel of 900 tons and only 230 feet long. She was built at Liverpool by a firm whose senior partner was a Member of Parliament.

Apparently no particular secret was made about the fact that the ship was intended for the Confederate Service, and Mr. Dudley, the American Consul at Liverpool, made urgent representations against the fitting out of the vessel.

He laid the facts before the American Minister in London, Charles Francis Adams, who called upon the British Government to stop the cruiser from entering the service of the Southern States. The Government, however, declared that it would listen to no complaints from the officials of the United States which did not furnish technical evidence for prosecution under the Foreign Enlistment Act.



The sinking of the Confederate cruiser *Alabama* by the *Kearsage*. The survivors of the *Alabama* are being rescued by an English yacht's crew

Mr. Dudley then set about finding the necessary evidence, and on July 21st, 1862, he sent a mass of documents to the Board of Customs in London, and urged that the vessel, which was then known by the number 290, should be instantly seized. He further asked that the authority to do this should be sent to Liverpool by telegraph, as the ship was now all ready to put out to sea and might escape at any hour.

Unfortunately, one of the British officials in London most concerned was ill, and so there was a delay of eight days before the matter was considered. During that time the "290" escaped from the Mersey, and after steaming about the north coast of Ireland for a day or two, proceeded to the Azores, where it was joined by another ship from London, the *Agrippina*, which had on board six guns, some hundreds of tons of coal, and large stores of ammunition and provisions.

These were intended for the *Alabama*, and were rapidly transferred to that ship. Two days later another British vessel arrived, bringing Raphael Semmes, who was to be the commander of the newly-built cruiser *Alabama*, together with a number of other officers.

There had certainly been very little concealment during the building of the *Alabama*, and now on August 24th, all pretence was swept away and the "290" unfurled the Confederate flag, took the name of *Alabama*, and started off on a tour of the ocean to prey upon the United States' commerce. It was one of the most wonderful voyages in naval warfare.

The *Alabama* started by destroying all American merchantmen in the eastern Atlantic, and then made a grand sweep across the ocean to within 200 miles of New York. Then she turned south to the West Indies, and by November had captured no fewer than 27 Federal vessels.

She had several narrow escapes from capture. While she was anchored at the island of Martinique, for example, the United States' warship, *San Jacinto*, suddenly appeared on the scene and nearly caught her, but she managed to get away.

She continued cruising about the West Indies, and ship after ship was captured or sunk by her. Then in the early spring of 1863 she swept down south as far as Bahia in Brazil, and turning eastward, went across to South Africa and later to the Bay of Bengal, making a prize of every American ship that came in sight.

For a year she proved a devastating scourge to American shipping in those waters, and in the spring of 1864 she sailed back past the Cape of Good Hope, capturing Federal vessels, and in July entered the harbour of Cherbourg in France.

A Challenge to Battle

It so happened that the Federal warship, *Kearsage*, was anchored some little distance off Cherbourg, and Captain Semmes, who could easily have escaped, but wanted to show that he was a real warrior and no pirate, challenged the commander of the *Kearsage* to battle.

The two vessels were nearly equal in size, and the *Kearsage* carried seven guns while the *Alabama* had eight, all of about the same calibre. There was thus apparently a slight advantage on the side of the *Alabama*, and no doubt Captain Semmes realised this and thought it would give him the victory. But Captain Winslow of the *Kearsage* readily accepted the challenge, and the two ships steamed out to neutral water seven miles from the French coast and then a great fight began.

Mr. Dudley urged instant action to prevent the *Alabama* escaping to sea

The *Alabama* fired first, sending two or three broadsides at the *Kearsage*, which was about 1,200 yards away. Little damage was done, and the two ships then circled round one another, gradually coming nearer and nearer till they were only 900 yards apart.

They fired with astonishing rapidity, sending broadside after broadside into each other, while thousands of people gathered on the shore watched the thrilling fight with bated breath.

While many shots missed, others did great damage, and one shot from the *Kearsage* which struck the coal bunkers of the *Alabama* exploded and killed or wounded 18 men.

For an hour the fierce fight went on, and then the *Alabama* ceased firing and made for harbour. The *Kearsage* promptly steamed across her bow, and was about to open a murderous fire upon her at close range, when she struck her colours and surrendered.

The *Alabama* was now sinking. Captain Semmes in his official report to the Confederate Naval Agent in Europe, says: "Although we were now but 400 yards from each other the enemy fired upon me five times after my colours had been struck, dangerously wounding several of my men. It is charitable to suppose that a ship of war of a Christian nation could not have done this intentionally.

"We now turned all our exertions towards the wounded and such of the boys as were unable to swim. These were despatched in my quarter boats, the only boats remaining to me, the waist boats having been torn to pieces,

"Some twenty minutes after my furnace fires had been extinguished and the ship being on the point of settling, every man, in obedience to a previous order which had been given to the crew, jumped overboard and endeavoured to save himself.

"There was no appearance of any boat coming to me from the enemy until after the ship went down. Fortunately, however, the steam-yacht *Deerhound*, owned by a gentleman of Lancashire, Mr. John Lancaster, who was himself on board, steamed up in the midst of my drowning men and rescued a number of both officers and men from the water. I was fortunate enough myself thus to escape to the shelter of the neutral flag, together with about forty others all told. About this time the *Kearsage* sent one, and then tardily another boat.".

Captain Semmes appears to have been mistaken about the apparent unwillingness of the *Kearsage* to hasten to the rescue of its foes. It would seem that Captain Winslow had himself asked the owner of the *Deerhound* to assist in the rescue, and he had sent his own boats as soon as he realised the need.

The original escape of the *Alabama* from England was unfortunate, and now another unfortunate incident occurred. The United States commander considered that, by every rule of warfare, the survivors of the *Alabama* were his prisoners, and in this claim he was supported by his government. It was considered unfair that the *Deerhound* should steam off with Captain Semmes and those of his fellow officers and men who had been rescued, and give them their liberty after they had struck their flag and surrendered to the *Kearsage*.

The American Minister in London, who had endeavoured to stop the *Alabama* from getting away, continued protesting throughout her career on the High Seas, and further protested against the saving of the officers from capture. But the British Government denied all liability.

"Her Majesty's Government," said Lord Russell, the Foreign Minister, "must decline either to make reparation or compensation for the captures made by the *Alabama* or to refer the question to any foreign state."

The dispute caused a good deal of ill-feeling, which can be easily understood. The American Government, which consisted chiefly of the triumphant North, were naturally annoyed when they remembered that in the early stages of the war England seemed to favour the Southern or Confederate States.

Two Points of View

They believed that this sympathy had had something to do with prolonging the war. They could not believe that the British Government had not deliberately allowed the Confederate cruisers to be fitted out in England and get away on their plundering raids so as to harass the North.

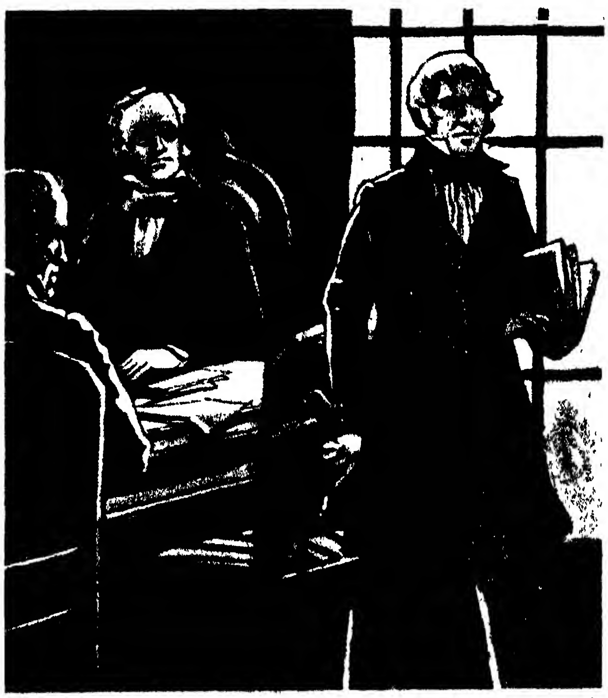
On the other hand, the British Government, at the period when the American Civil War broke out, had not got over the habit of regarding the United States as an upstart nation of little importance, and it was inclined to treat with scant consideration any protests from that nation about the action of British subjects.

It was the sort of dispute which has many a time in history brought about a destructive war, and it might easily have done so in this case. But fortunately calm councils prevailed. At the instance of England a joint High Commission was appointed to sit in Washington, and discuss some method of arriving at a peaceful settlement of what came to be known as the Alabama Claims.

All American statesmen were not agreed as to what the amount of these claims should be. One statesman, Mr. Charles Sumner, made a speech in the American Senate, in which he claimed not only £3,000,000 for the capture and burning of American vessels, but a further £22,000,000 for loss to the American carrying trade.

He did not even stop there, but declared that as the prolongation of the war was traceable directly to England and that the war must have been doubled in duration thereby, he suggested that the British Government should be called upon to pay a large part of the expenses of the war. It was suggested that at least a thousand million dollars, or £200,000,000, should be demanded.

Of course, such claims were as extravagant and ridiculous on the one side as the declaration of some English statesmen that there was nothing at all to discuss, and that America had no real grievance worth considering.



When the decision was given Sir Alexander Cockburn took his hat and left the room without any proper farewell

Wiser men on both sides, however, instead of talking about fighting or resistance, met in Washington and discussed the matter. As a result a Treaty of Washington was signed and proclaimed on July 4th, 1871, by which both governments agreed to refer their dispute to a Tribunal of Arbitration, consisting of one arbitrator from England, one from the United States, and one each appointed by the governments of Italy, Switzerland and Brazil.

This Tribunal met at Geneva later in the year. In the Treaty the United States Government maintained that during a war a neutral government is compelled to be diligent in preventing the fitting out, arming, or equipping within its territory, of any vessel which there is reasonable ground to believe is intended to carry on war against a power with which the government in question is at peace.

The American government also maintained that no neutral power should allow either of the parties at war to make use of its ports or waters as a base for naval operations against the other, or to renew its supplies of men or armaments.

Great Britain, on the other hand, denied in the Treaty that these rules were a true statement of the principles of international law as that law stood during the American Civil War. It agreed, however, to abide by those principles in future, and also consented to the *Alabama* Claims being decided in accordance with them.

The Tribunal held its first meeting at Geneva on December 15th, 1871, under the Presidency of the Italian representative, and it adjourned till the following June. Then when it met again it decided that Great Britain was actually responsible for the damage done by the *Alabama*, and on September 14 of the same year it decided by a majority of four to one that Great Britain should pay to the United States as an indemnity for the damage done 15,500,000 dollars in gold, equal at that time to £3,230,000.

A Graceless Action

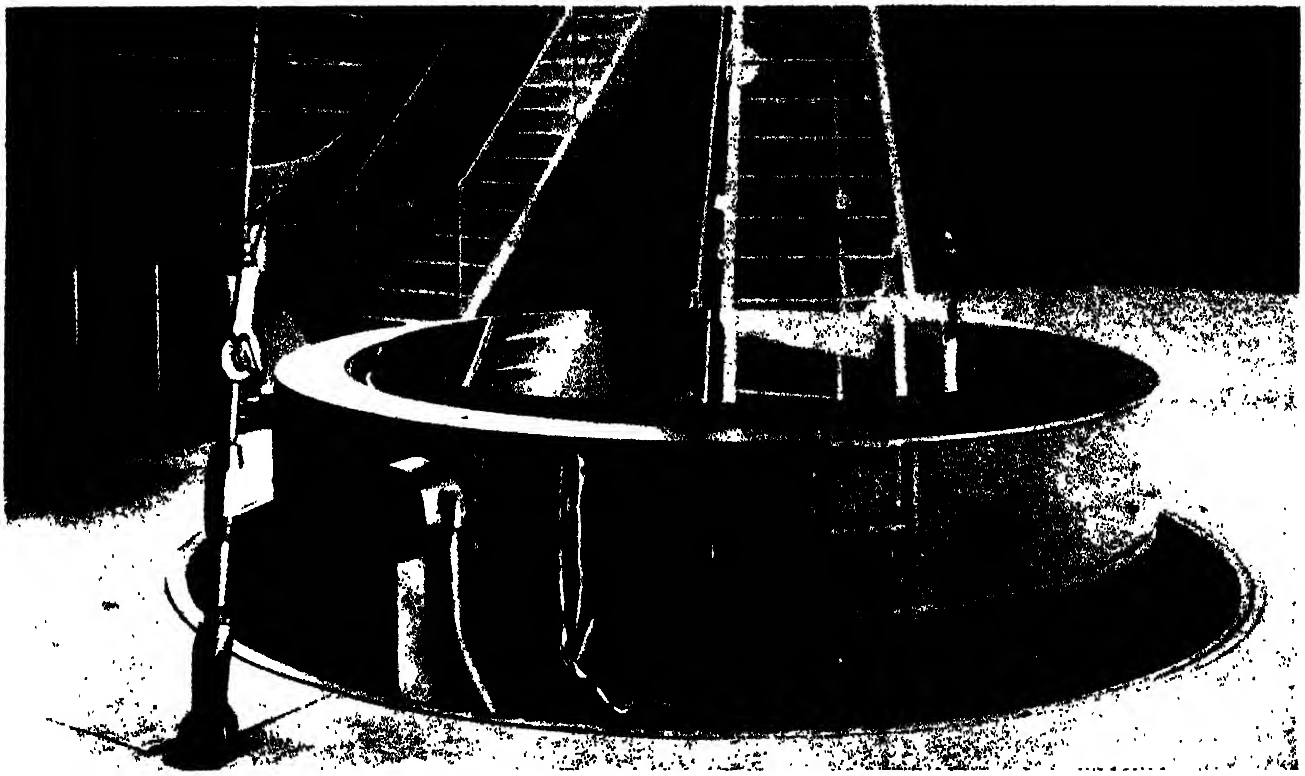
It was perhaps unfortunate that the member forming the minority against this decision, who was the British representative, Sir Alexander Cockburn, refused to sign the Award and on its announcement took his hat and left the room without any proper farewell. But the British Government accepted the Award and paid the amount.

So ended the *Alabama* case which had stirred the world, roused bitter feelings in two lands and brought England and the United States, if not within reach of war, at any rate to a state of great hostility.

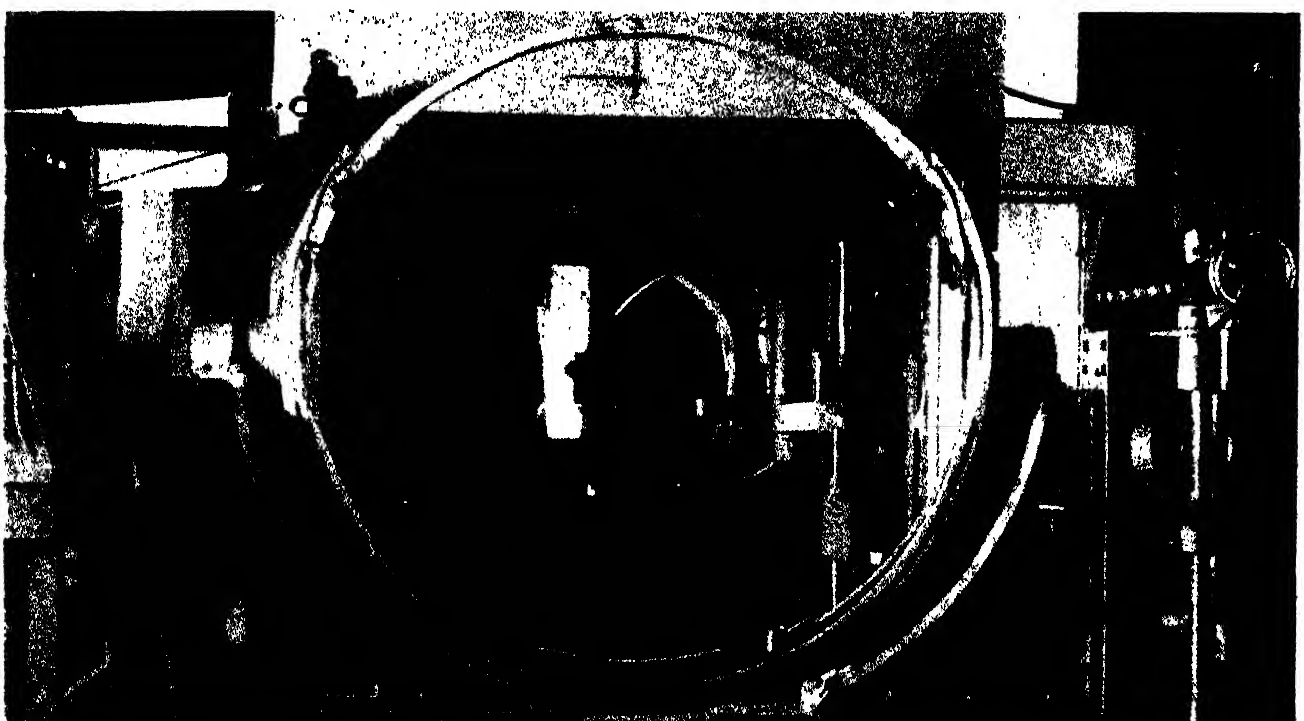
There was much to regret in the *Alabama* case, but we must remember that it provided a magnificent object lesson to the world of how, when feeling is running high and hotheads are urging reprisals, two great nations can discuss the dispute calmly and fairly and settle it without bloodshed entirely by arbitration.

The *Alabama* Claims cost Great Britain about three and a quarter million pounds, but what would have been the cost in lives and money if the two countries had gone to war instead of settling their differences by arbitration? If only the dispute between Austria and Serbia which led to the Great War could have been settled in the same civilised fashion!

KEEPING A 5-TON MIRROR CLEAN AND BRIGHT



This photograph shows the 100-inch mirror of the telescope at Mount Wilson Observatory, California. It weighs nearly five tons, and the glass, after it was made, took two years to polish. The expense of keeping it in working order is very great, as it has to be resilvered twice a year. When it is to be resilvered the mirror is lowered through the floor by a lift to an apartment below



For the silvering process a band is drawn tightly round the mirror, which is mounted so that it can be slightly rocked. The old silver is then removed with acid and the glass given a thorough cleaning with cotton swabs. The silver solution is then poured on and kept in motion for a time, the spent solution afterwards being poured off. The thickness of the silver deposit is only 100,000th of an inch. The mirror is next washed again and dried with chamois leather skins. Then a big chamois leather pad, three feet in diameter, and revolved by an electric motor, burnishes the mirror with a circular motion. The resilvering takes twelve men one day to complete

WONDERS OF THE SKY

SPOTS THAT APPEAR ON THE PLANETS

Most people think that the appearance of a spot on a planet which disappears after a few months or a few years, though it may be of interest, is of little importance. But it is by means of these spots that astronomers are able to learn a great deal about the character of the planet itself. Here we read something about spots that have appeared on some of the planets from time to time

In August, 1933, a curious white spot was discovered on the planet Saturn by an amateur astronomer who was watching this world through his telescope in London. Afterwards the spot was seen by many professional astronomers, but it was a great credit to the amateur astronomer, Will Hay, who was by profession a comedian, that he was the first man to notice it.

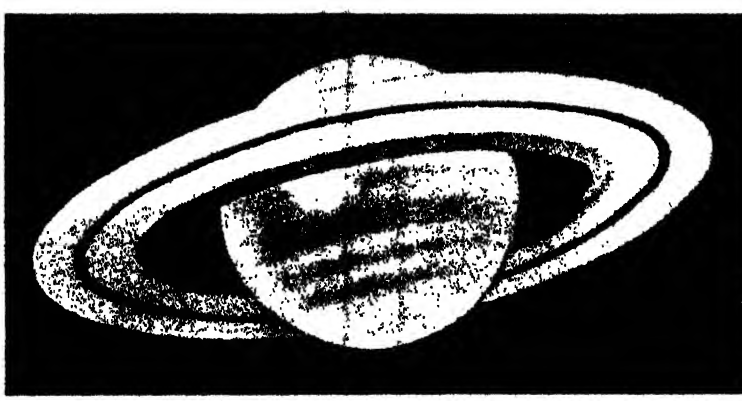
The spots that appear on the planets from time to time are of great importance, for they help our knowledge of other worlds in two ways. First of all by watching them we are able to see whether they are permanent markings attached to the body of the planet, or whether they are merely temporary phenomena. This kind of observation enables us to learn something about the condition of the planet itself.

In the second place, by watching the spot as it moves across the planet's face and, after travelling round the other side, returns to the visible side again as viewed from the Earth, we are able to know with fair accuracy how long the planet takes to turn round on its axis.

The most notable spot that has ever appeared on a planet was the great red spot of Jupiter, which became prominent on that planet in 1878, and was very conspicuous for several years, and then gradually faded till it became almost invisible.

The spot changed in size from time to time, and its position varied on the planet. At its largest it was 30,000 miles long by about 7,000 miles wide. No satisfactory explanation of it has been given, although some astronomers suppose that it was the result of the surface of the planet being rent asunder by a kind of volcanic eruption, so that a vast area was flooded with fiery masses which sent up hot currents, separating the cloud belt surrounding Jupiter.

The great red spot on Jupiter as it appeared during its greatest extent. The spot varied in size, but was at one time 30,000 miles long and at least 7,000 miles wide



The planet Saturn, showing the white spot that was discovered on its surface by Will Hay in August, 1933

The redness of the spot was supposed by these authorities to be the fiery glow showing through the mists. The red spot remained quite plainly visible for a quarter of a century.

Saturn's appearance is very much like that of Jupiter, and it is almost certain that we see only its atmosphere, and not its actual surface. The spot on Saturn may have been due to some similar sort of outburst on that planet's surface.

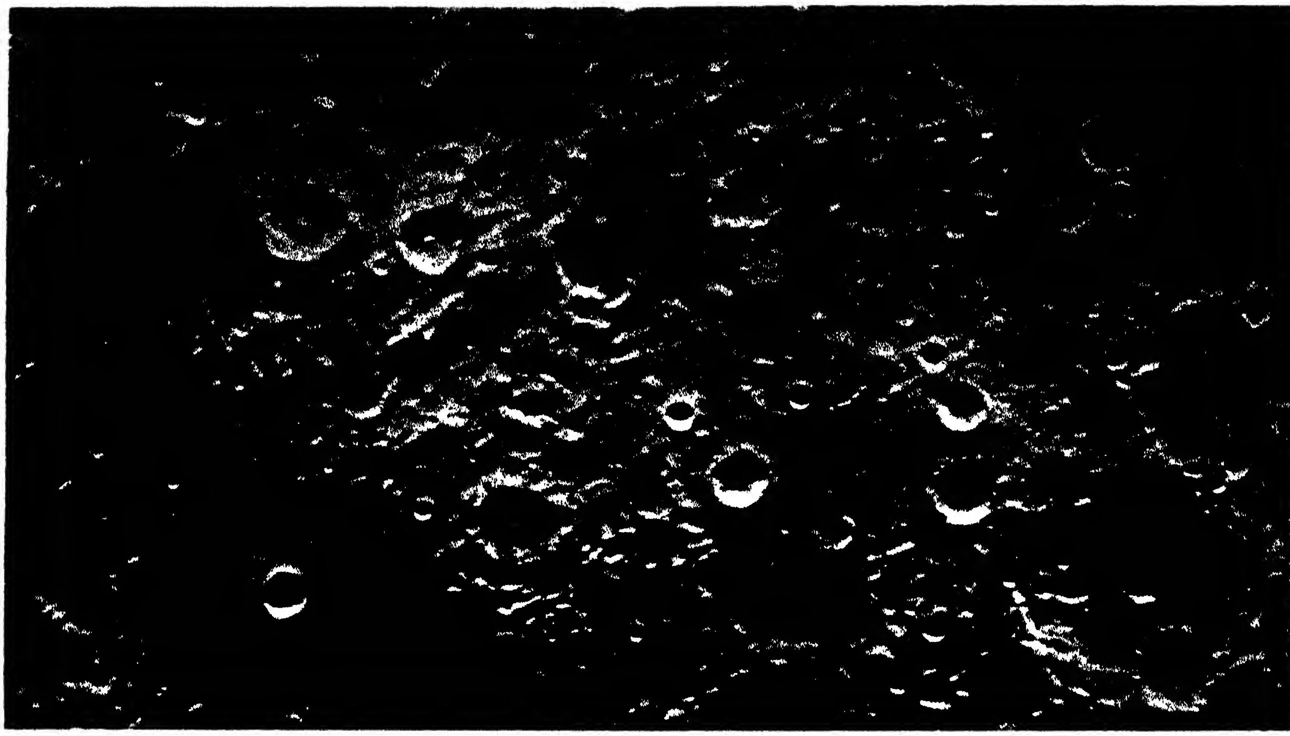
We know the great red spot on Jupiter was not permanently attached to the body of the planet, for during the first six or seven years of its appearance it lengthened its rotation period by about six seconds, that is, it did not go round and come back to the same position relative to the Earth in exactly the same period every year. There was a slight difference.

There are no permanent markings found on either Jupiter or Saturn. The great cloud belts on Jupiter move very rapidly and go through many transformations.

Quite different are the white spots that appear from time to time in the polar regions of the planet Mars. These wax and wane with the seasons disappearing in the summer of the planet, and reaching their greatest extent during its winter. Astronomers are agreed that these white spots at the poles indicate the presence of snow, or possibly frozen carbon-dioxide, just as the Earth's poles would present white spots to a distant observer, increasing in winter and decreasing in summer.

On Mercury permanent markings have been noted, and on Venus dark shadings which some have thought might be continents and oceans. But as they remain permanent during the different phases of Venus, they are more likely to be atmospheric effects.

CLOSE-UP VIEWS OF LUNAR LANDSCAPES



The surface of that side of the Moon which faces us is better known than some parts of the Earth, for by means of the big telescopes and the camera we can get photographs that give exact representations of the landscape, and by means of the shadows we can measure to within a few feet the height of the mountains and crater walls. Here is a lunar landscape showing in the bottom right-hand corner the great walled plain of Albategnius. It is 65 miles in diameter, and on one side a peak towers to a height of 15,000 feet. On the left of the photograph we see a great cleft running for many miles across the Moon's surface

Here is another lunar landscape showing the Apennine Mountains on the right and the Alps on the left, with a great Alpine valley like a straight cut. The big crater at the bottom is Archimedes, and the two above it, Aristillus on the left and Autolycus on the right. Further to the left is Cassini, and above it the Caucasus Mountains. The flat surface in the lower part of the photograph is the Sea of Rains, and that at the top is the Sea of Serenity. The photographs are reproduced by courtesy of the Royal Astronomical Society

WHAT WE MEAN BY SPECIFIC GRAVITY

Some substances are light and others heavy, this depending upon the amount of matter in a given volume. In comparing substances we speak of their specific gravity, which means their weight compared with the weight of an equal bulk of some other matter. The standard for deciding the specific gravity of solids and liquids is distilled water at 62 degrees Fahrenheit. The specific gravity of water is called 1, and a substance of which an equal volume would be twice as heavy is said to have a specific gravity of 2

THERE is in the Old Testament a story of a man who was chopping wood when suddenly the axe-head flew off the handle and fell into the River Jordan. He was very upset, for the axe had been borrowed.

According to the old story the Prophet Elisha who was standing by caused the iron to swim so that the man could recover it. Teachers, of course, refer to this as a miracle, and we can quite understand their doing so, for we know that a solid mass of iron, if it falls into water, always sinks to the bottom.

If we were asked for an explanation of that fact we should probably say that objects heavier than water sink, while those lighter than water float. But that is not an explanation, nor is it a complete statement of the truth. What we really mean is that an object which is heavier than an equal volume of water sinks, while one that is lighter than an equal volume of water floats.

A nail, for instance, dropped into a basin of water sinks to the bottom, but a cork dropped into water floats on the top with only part of its substance immersed. Even if with our hand we press the cork to the bottom of the basin, as soon as we remove our hand the cork will float up again.

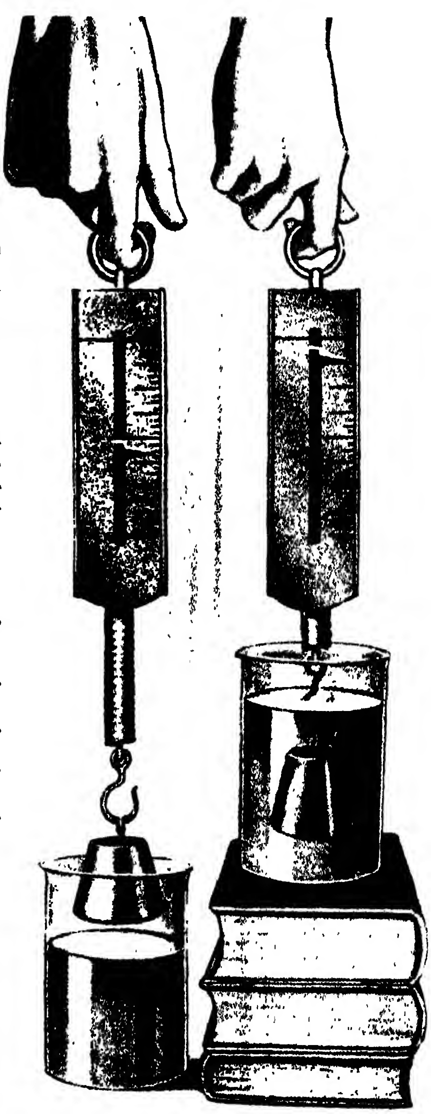
Differences in Density

The reason that different substances behave thus differently in water is that their densities are different; that is, the amount of matter in a given volume varies with the different substances. A cubic inch of lead, for example, is exactly the same size as a cubic inch of cork, but it contains a great deal more material and so we say it is denser.

In comparing the different substances we assume, of course, that the conditions are the same, as, for example, the temperature.

A few examples will show us how very much the densities of different substances vary. A cubic foot of water at 4 degrees Centigrade weighs 62·4 pounds or, in other words, the mass of a cubic foot of water is 62·4 pounds. But a cubic foot of copper weighs 555 pounds; of silver 658 pounds; of lead 708 pounds, of mercury or quicksilver 848 pounds; of gold 1,207 pounds, and of platinum 1,340 pounds. We, therefore, say the density of water is 62·4 pounds per cubic foot, of copper 555, and so on. The denser a substance is the more closely are the molecules or particles of which it is formed packed together.

Scientists usually reckon densities not in feet and pounds, but in cubic centimetres and grammes. One cubic centimetre of water weighs one gramme; of copper 8·9 grammes, of silver 10·53 grammes, and so on. In speaking of the density of a substance, therefore, we must always note what system of units we are using; as, for example, feet and pounds, cubic centimetres and grammes, or any other system.



A simple experiment to show that an object loses weight when immersed in water. The loss is equal to the weight of water displaced, a fact discovered by Archimedes

Now as we see from the figures given, copper is rather more than nine times as heavy as a similar quantity of water, and gold more than nineteen times as heavy. Men of science, therefore, compare all liquid and solid substances with water, and speak of their specific gravity, which means how many times heavier or lighter they are than an equal quantity of water.

As we have seen, in speaking of the density of substances we must know what system we are using, as the figures are different in the case of cubic feet and pounds from what they are in cubic centimetres and grammes. But there is only one table of specific gravity, for whichever system of densities we are using copper is always 8·9 times as heavy as water and gold is always 19·3 times as heavy. It should be explained that in reckoning the specific gravities of gases, instead of using water as the standard, air is used, its specific gravity being reckoned as 1.

Finding the Density of a Solid

When we know the specific gravity of a substance as, for example, bronze, which is 9, we know that any quantity of bronze would weigh nine times as much as the same quantity of water—a cubic inch, foot, or yard. We could always find the specific gravity of a substance by dividing the weight of any volume of it by the weight of an equal volume of water.

We find the density of a solid heavier than water by first finding its mass and volume. The mass is discovered by weighing, and the volume by a principle which was discovered by the great Greek philosopher Archimedes about 250 B.C.

King Hiero of Syracuse was in a difficulty, and he sent for Archimedes, who was a relation of his. The King had handed to a goldsmith a certain weight of gold with which to make a crown. When the crown was delivered the King for some reason or other suspected that the goldsmith had not used all the gold, but had stolen some of it and mixed the remainder with some silver in order to make up the necessary weight.

The King asked Archimedes, whom he knew was very clever, to discover whether the crown was made of pure gold or not. Of course, in those days there were no acid tests such as we have to-day

Here was a difficult problem for the philosopher. The weight of the crown was undoubtedly the same as the weight of the gold handed to the goldsmith, and the crown looked as if it were made of pure gold.

Archimedes thought over the matter for a long time, and then he hit on a wonderful plan. He took pure gold and pure silver and made two blocks, one of gold and one of silver, each weighing exactly the same as the King's crown. Archimedes found that the silver block was a good deal larger than the gold block. If, therefore, some of the gold had been replaced with silver in the crown, the crown would be bigger than it would have been had it been made entirely of pure gold. But as it was of such an irregular shape, how could he possibly find this out?

"Eureka! I have found it!"

It is said that the solution of the problem came to him like a flash. One day he was having a bath in one of the large cup-shaped baths which were used in that day, and before he entered it the bath was full to the brim.

When he got in, of course, a good deal of the water flowed over the edge, and when he left the bath Archimedes saw that the water was no longer up to the brim. It came to him as an inspiration that the amount of water that had overflowed must be exactly equal to the volume of his own body, that is the space his body occupied was the same as the space the displaced water occupied. He would find the volume or cubic contents of the crown in the same way.

It is said that in his excitement at this great discovery Archimedes forgot to dry and dress himself, but rushed out as he was into the street, shouting "Eureka! Eureka!" which means "I have found it! I have found it!" People probably thought he had gone mad, but on reaching his home, for he had been at the public baths, he took the crown and lowered it into a vessel full to the brim with water, collecting every drop of the water that overflowed.

Then he did the same thing in turn with the blocks of gold and silver which he had made, and which were of exactly the same weight as the crown. When he compared the three volumes of water that had overflowed he found that the crown, while it displaced less than the silver block, had displaced more water than the gold block. Therefore, said he, this crown is not made of pure gold but contains some silver.

The story goes on to tell us that by

Archimedes, after a bath, hits upon a great discovery

mixing gold and silver in different proportions and testing the result he at last obtained a mixture that displaced exactly the same amount of water as

Archimedes, by placing the King's crown in the water, discovers a goldsmith's fraud

did the crown. Then he was able to tell the King not only that the goldsmith had stolen some of the gold, but exactly how much he had stolen.

The method thus invented by Archimedes of finding the volume of a solid body of any shape is still followed. A special vessel is used for the water, which is called a Eureka Can. It is simply a tin vessel with an overflow pipe which carries off the water displaced when a solid is lowered into it. The water displaced is then measured with a measuring jar, and gives the exact volume of the solid.

To return to the method of discovering the density of a solid heavier than water. Having found the mass and the volume it is easy by a simple calculation to find the density. For example, if a body whose mass or weight is 10 grammes displaces 2 cubic centimetres of water, which, as we know, weigh 2 grammes, then the volume of the body is 2 cubic centimetres. The density of the substance therefore must be 10 divided by 2, which gives as the result 5 grammes per cubic centimetre. From this also we know that its specific gravity is 5, which means that it weighs five times as much as an equal volume of water.

Methods of Discovery

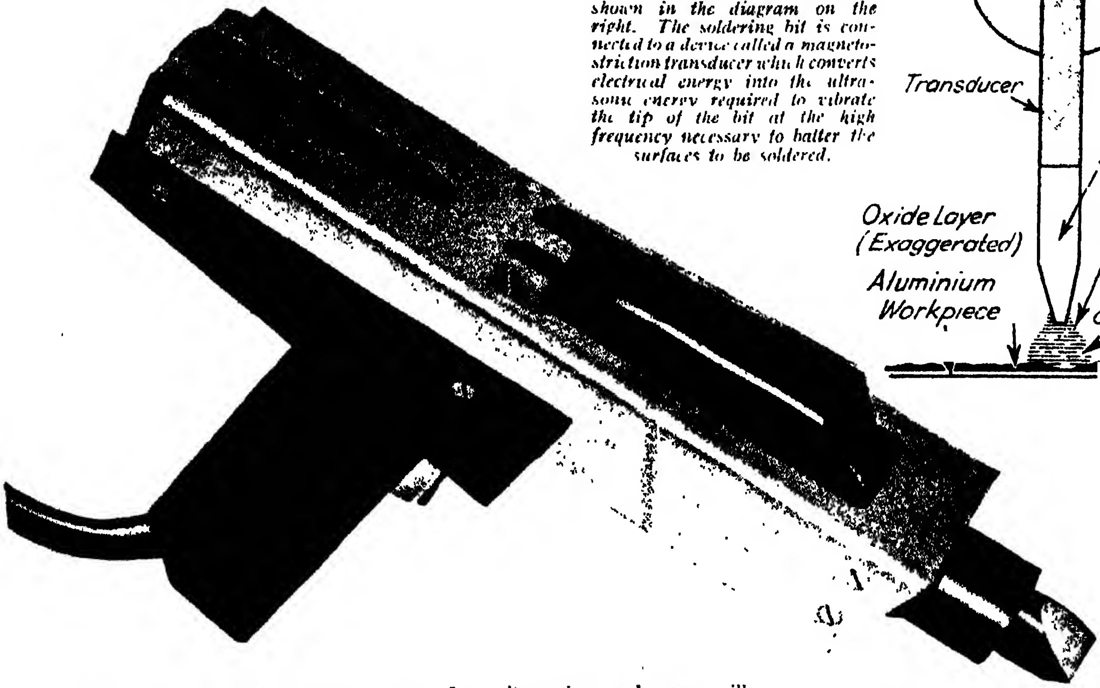
For solid substances that dissolve in water other methods of finding the volume are used.

To find the density of a solid lighter than water the following method is used. The body is first weighed in air, then a sinker is attached to it and the body is weighed again with the sinker only, in water. A third time we weigh with both body and sinker in water. Then we subtract the weight when both are in water from the weight when the sinker only is in water, and divide that result into the weight of the body in the air. The answer gives the density in grammes per cubic centimetre and also the specific gravity of the body.

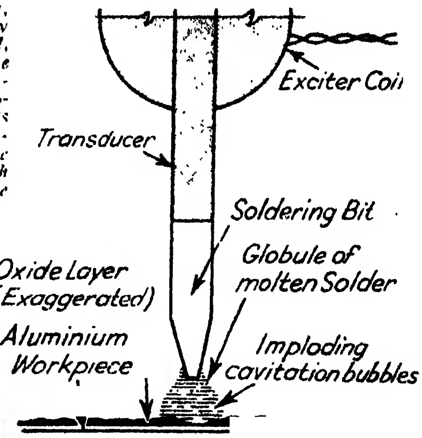
To find the density of a liquid there are various methods. The simplest method is to use an instrument called a Hydrometer, which indicates the density by the depth at which it floats in the liquid. The density of a gas is found by weighing a given volume under certain conditions.

Air is extracted from a globe and the empty vessel is weighed. The gas to be tested is then passed into the vessel until the pressure is the same as the atmospheric pressure outside. The vessel is allowed to stand until the gas acquires the temperature of the outside air. It is then again weighed, and its gain in weight is the weight of the gas inside. The globe is then again exhausted and filled with air, which is weighed, and the weight of the gas compared with that of the air.

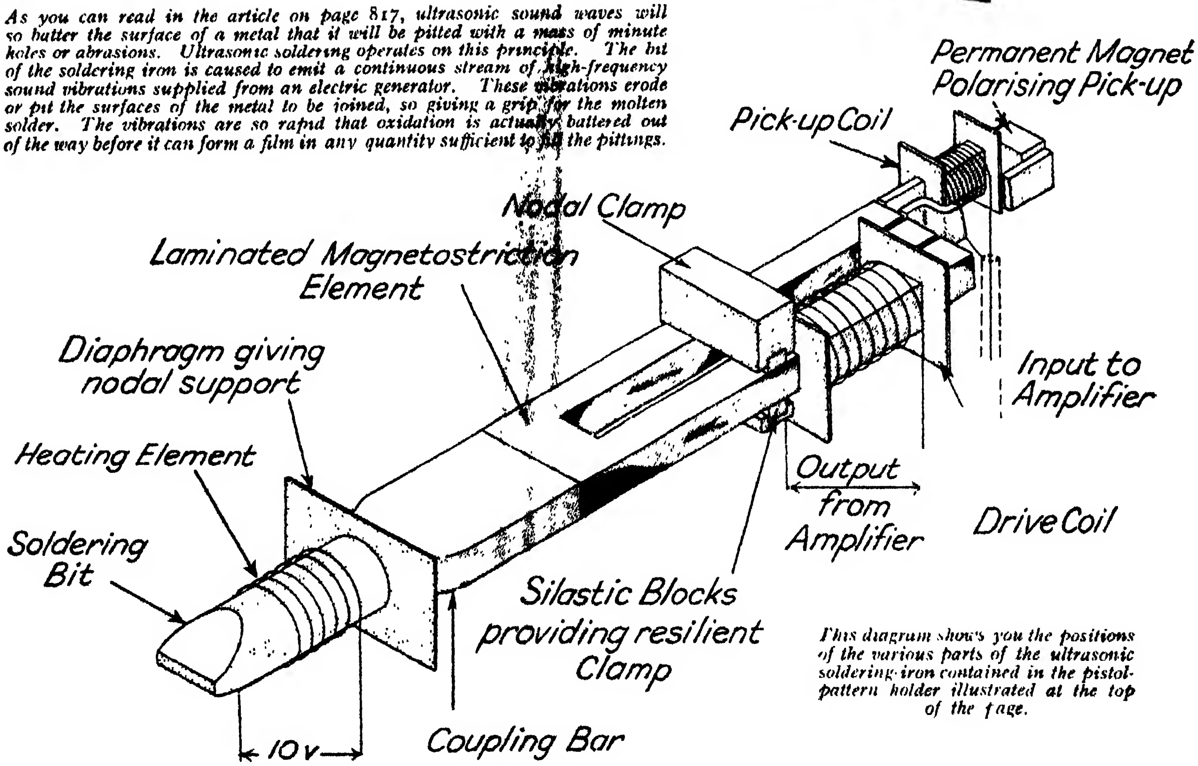
USING NOISE TO SOLDER ALUMINIUM



The ultrasonic soldering iron, shown on the left, is electrically heated through the exciter coil, shown in the diagram on the right. The soldering bit is connected to a device called a magnetostriction transducer which converts electrical energy into the ultrasonic energy required to vibrate the tip of the bit at the high frequency necessary to batter the surfaces to be soldered.



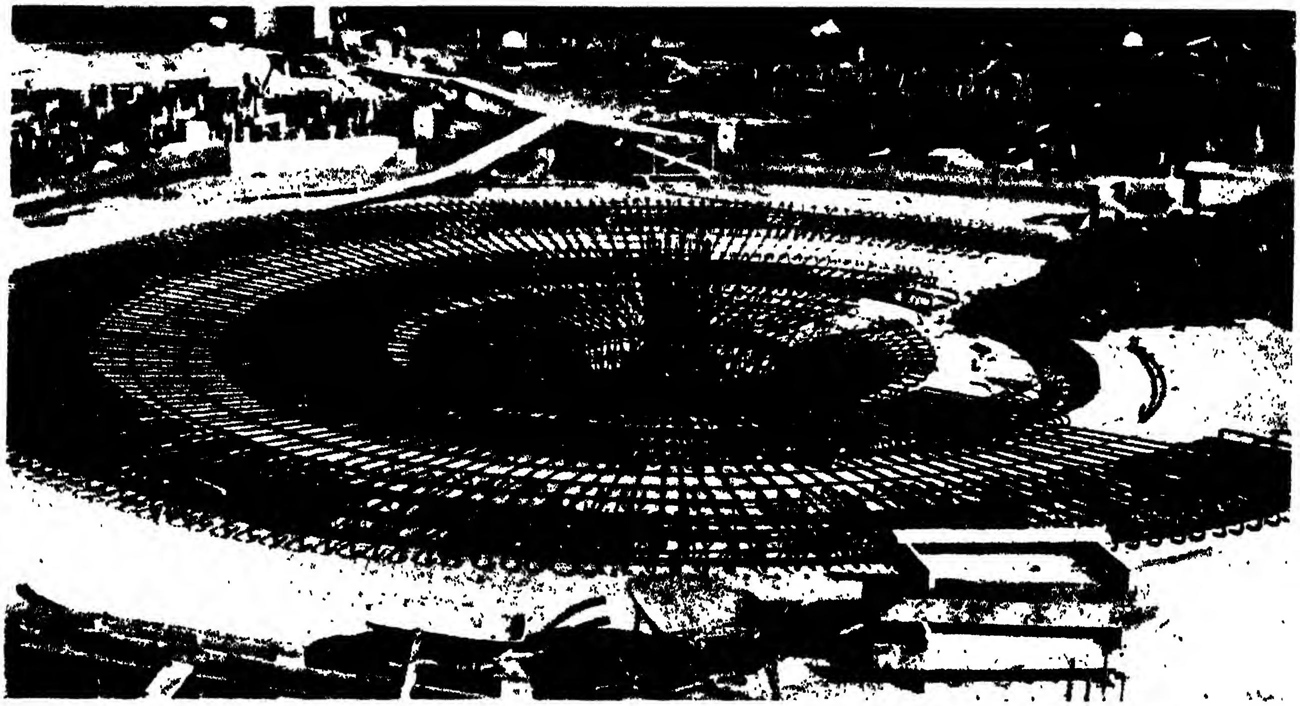
As you can read in the article on page 817, ultrasonic sound waves will so batter the surface of a metal that it will be pitted with a mass of minute holes or abrasions. Ultrasonic soldering operates on this principle. The bit of the soldering iron is caused to emit a continuous stream of high-frequency sound vibrations supplied from an electric generator. These vibrations erode or pit the surfaces of the metal to be joined, so giving a grip for the molten solder. The vibrations are so rapid that oxidation is actually battered out of the way before it can form a film in any quantity sufficient to fill the pittings.



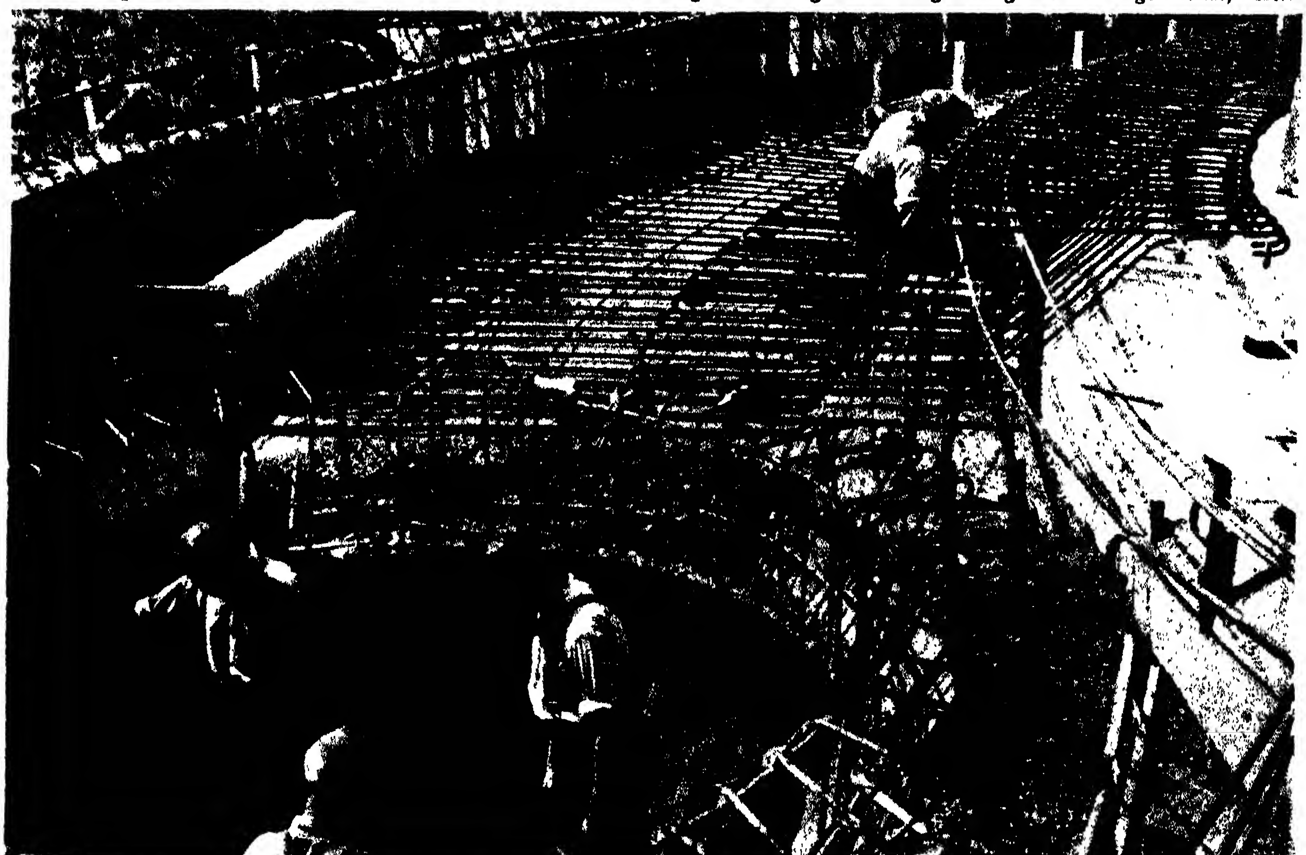
This diagram shows you the positions of the various parts of the ultrasonic soldering-iron contained in the pistol-pattern holder illustrated at the top of the page.

Most metals and metal alloys can be soldered or joined together by running between their edges a film of molten alloyed metal (the solder) which has a lower melting point than the metal being joined. The surfaces to be joined must be absolutely clean and free from grease and oxide film, which is done by use of a flux. The flux does this by dissolving the oxide, and the flux must continue to dissolve the oxide at the soldering temperature because new oxides are continuously formed at such temperatures. In other words, the edges of metal to be joined must have roughened edges : the roughening consisting of minute pittings which provide a surface against which the solder can grip. In certain metals, mostly of the aluminium group, oxidation forms so fast on the edges to be soldered during the application of heat from the soldering iron that there is no pitting of the edges upon which the solder can grip, so that no joint is formed. But with the ultrasonic soldering-iron shown above, which uses sound vibrations instead of heat, oxidation can be stopped long enough for the molten solder firmly to grip the edges of the aluminium

SCIENCE APPLIED TO BUILDING CONSTRUCTION



The greatest advance in building since the nineteenth century has been the application of steel reinforcement to concrete. Each strengthens the other, for the steel bars bind the concrete, while the concrete preserves the steel from corrosion. Changes of temperature affect both equally ; this is of the greatest value in building, as steel and concrete expand together under heat and contract together in cold. Here we see the reinforcement for a settling tank during the building of Dagenham Sewage Works, Essex.



Here is another photograph taken while the Dagenham Works were in course of construction, and it shows clearly the way in which the steel is arranged in the concrete. The concrete is poured in liquid form over the reinforcement and then settles hard, the adhesion between the concrete and the embedded steel bars being very great. A steel bar embedded in good concrete will tear in two before it can be withdrawn. These photographs are given by courtesy of the British Reinforced Concrete Engineering Company, Ltd.

DIVERS WHO SWIM LIKE FROGS

BECAUSE it has large, flat, webbed feet, the frog is a fast and expert swimmer under the water; unlike a man in the ordinary type of deep-sea diving suit who is so weighted down with equipment that the best he can do under the water is to walk very slowly. It was this inability of the diver to move about easily or quickly that during the 1939–45 war led to the invention of what is called the frogman diving dress.

The frogman diving dress is so called because its design was decided upon only after a careful study of the frog's behaviour in the water. As you see in the pictures on this page, a man wearing the suit looks rather like a frog. Not only does he look like a frog, but his self-contained breathing equipment and the large flippers attached to his feet make it possible for him to swim faster and to stay under water longer than a frog can.

During the Allied preparations for the invasion of Europe it was realised that the German underwater defences off the French coast would have to be destroyed before landing craft could attempt to put troops or equipment ashore. Most of these defences consisted of rows of steel spiked-posts ten feet high and ten feet wide and weighing two tons. The posts had mines and other explosives attached to them, so that any craft striking against them would be blown up.

Experiments proved that attempting to destroy the obstacles by gunfire would leave many of the posts standing, and also that the shells would tear such gaps in the beaches that men and equipment could not be landed. It was thereupon decided that the obstacles could be destroyed only by fixing explosive charges to their bases.

Accordingly, the British Admiralty, which was responsible for clearing the proposed landing beaches, ordered a diving suit to be designed that would make it possible for a man to swim under water, leaving his hands free to carry out the delicate work of fixing explosive charges, and give him protection against cold and injury from underwater explosion of shells or mines.

The new diving suit was made in one piece from a rubber-like cloth and covered the wearer from the soles of his feet to the crown of his head. Instead of a diving helmet, there was a strong glass front Attached to the facepiece was a rubber tube through which the wearer breathed oxygen from bottles strapped on his chest. The bottles held enough oxygen to last 90 minutes.

The feet of the suit were extended into long rubber flippers that enabled the diver to swim under the water as fast as an expert on the surface.

After prolonged tests of the equipment in swimming baths and bathing beaches, a unit called the Landing Craft Obstruction Unit was formed in 1943.

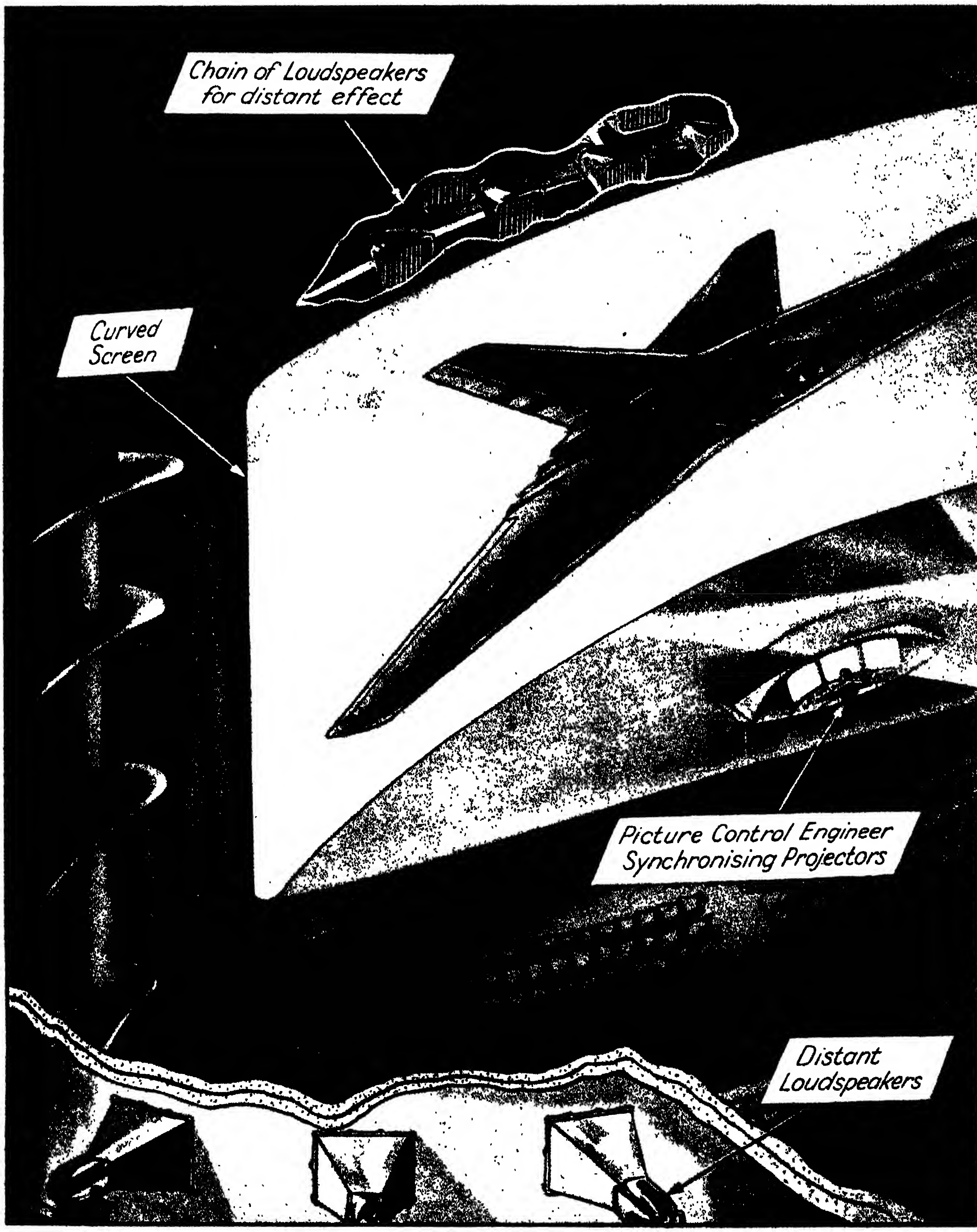
Five hours before the Allied troops landed on the Normandy beaches on D-Day (June 6, 1944), the Landing Craft Obstruction Unit went into action and cleared over 3,000 obstructions at a cost of only one casualty

Frogman suits were also used by divers who cut a way through harbour defence nets to allow submarines to attack enemy ships at close range. Other frogmen were employed to attach limpet mines to the bottoms of enemy ships at anchor.

The frogman diving suit has also been found useful for many civilian purposes. Frogmen have been employed in the inspection and repair of bridge and harbour foundations, and for salvaging vehicles and other objects which have fallen into harbours and rivers. Divers who collect pearls often wear frogman suits.

The first photograph shows you a frogman ready to make a dive. In 2, frogmen are coming ashore after an underwater swim. In the third photograph a frogman is moving about close to the bottom of a swimming bath. The fourth photograph is of a taxicab which fell into a harbour and was salvaged by frogmen.

CINEMA THAT USES THREE PROJECTORS

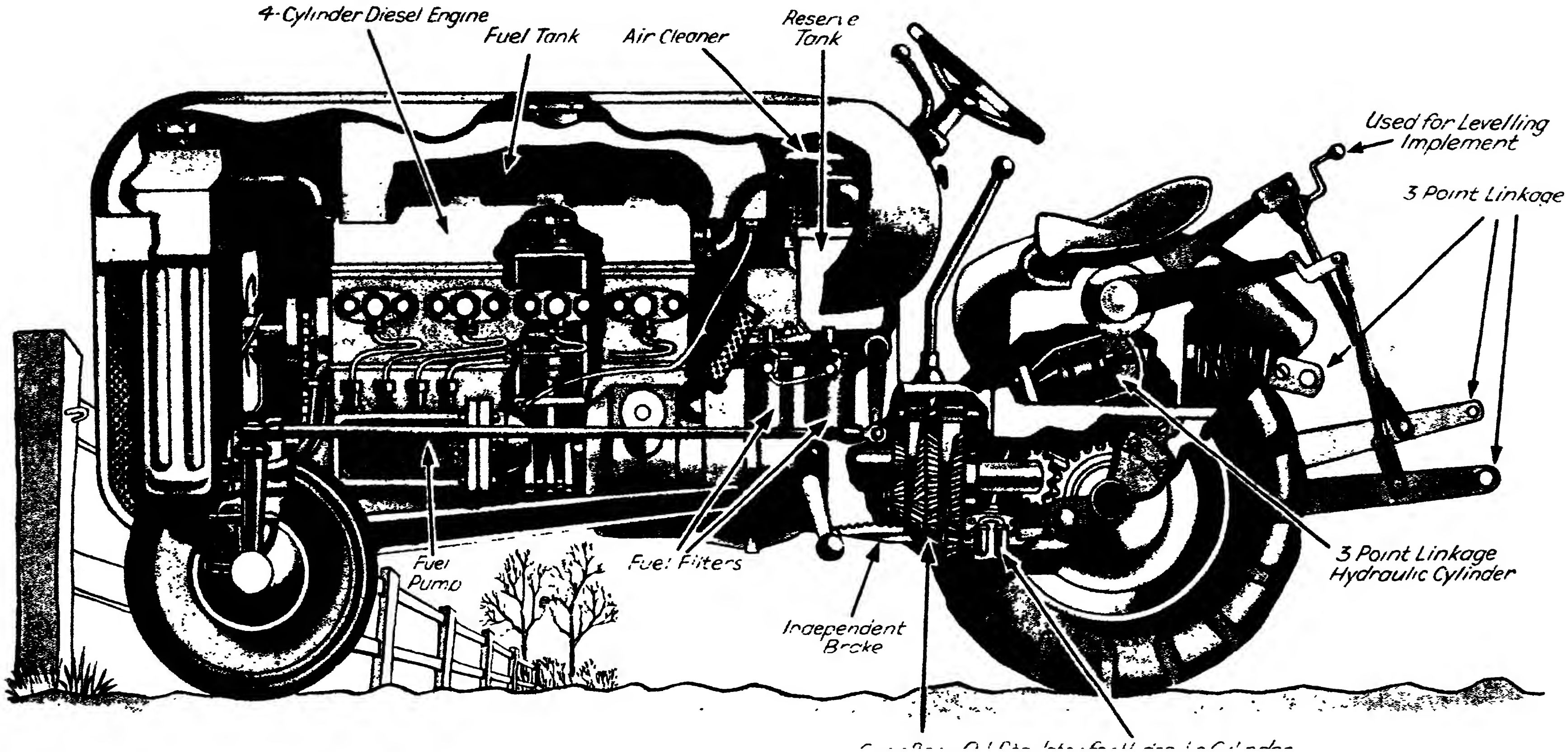


Although the cinema gives a good illusion of movement in the picture projected on the screen, the picture is always flat, like a snapshot photograph, and tends to be distorted when viewed from different angles. Similarly with the sound of a talking picture : a character may be speaking from one side of the screen, but his voice appears to come from the centre of the screen, behind which the loudspeaker is mounted. A snapshot can be given the illusion of depth by viewing it through a stereoscope as explained in pages 409-411, but this is impossible in a cinema, and the next best thing is to provide the audience with stereoscope spectacles. In 1951 an entirely new approach to the problem was made by the cinerama system. In this the picture is taken by a camera having three lenses, each of which records in perfect synchronisation one third of the scene to be shot. The three films thus obtained are then simultaneously projected, each from its own projector, on to a concave screen, 64 feet wide and 23 feet high, so

TO CUT OUT MOTION PICTURE DISTORTION

that each projector covers exactly one third of the screen's surface. In this way, every member of the audience, irrespective of the angle of view, sees characters on the screen exactly as a theatre audience sees players. A spectator sitting at the side of the cinema, does not get a distorted view of the object on the screen but sees it in its proper proportions. Similarly, sound comes to the audience from the direction of its apparent source. Thus, when an actor on the left side of the screen speaks, his voice comes from that source. This is done by having banks of loudspeakers so arranged that they are switched on to agree with lateral (side to side) and vertical (up and down) movements on the screen. When, for example, an aeroplane zooms across the screen, the noise of its engines seems to follow the image. The cinerama system of sound film projection was first tried out in Britain in the Royal Festival Hall, London. Experiments have been made to apply the technique to television.

TRACTOR THAT DOES THE WORK OF 35 FARM HORSES



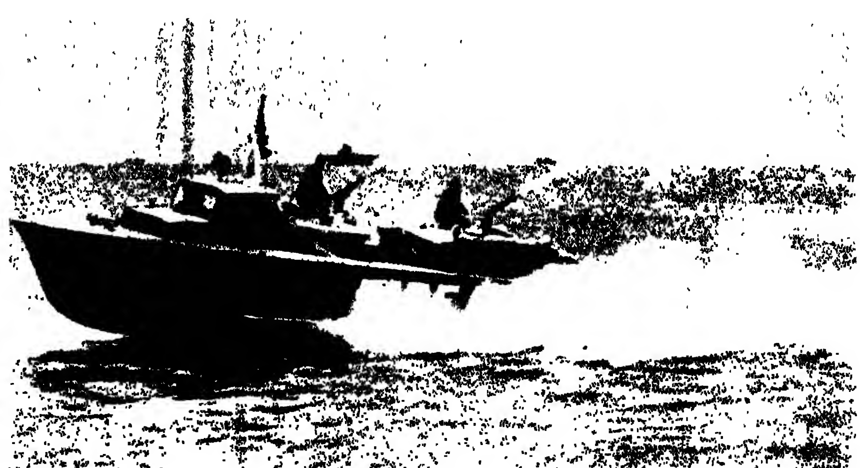
Although man could never have farmed on a large scale unless he had domesticated and trained the horse to pull his ploughs, harrows, reapers and wagons, the horse is rapidly disappearing from Britain's farm-lands. Over the ten-year period 1939–1949, the number of horses on farms in England, Scotland and Wales declined from 1,083,000 to 617,000. Within a few years it is likely that the horse, as the provider of farm power, will have been replaced entirely by tractors of the type shown in the above drawing. Horses need too much labour to look after them and too much land to grow their food. Moreover, a horse must be fed even when it is not working, whereas a tractor does not consume fuel after its work is done. Tractors can be powered by petrol, paraffin, or, like the one shown above, by diesel engines. The main parts are very much the same as those of a motor-car or lorry. But the tractor has no road springs, and its component parts are bolted rigidly to the back axle. The forward speeds of a tractor are much lower than those of a road vehicle, consequently the reduction in gear ratio between engine and driving wheels is greater. The engine must be able to develop its full power when the tractor is moving at speeds as slow as two miles an hour. A tractor's front wheels are small in comparison with the rear wheels: this is to make steering easy and to prevent the front of the tractor jumping up on rough ground. The rear wheels have large rubber tyres with deep ridges or treads, so that they can grip the ground without sinking into it. The tractor above, which has been drawn as if cut through the centre to show you what it is like inside, is of 35 horse-power. The three-point linkage at the rear is for attaching farm implements. It is so arranged that it can lift a plough clear of the ground when the tractor turns. The linkage also stops any excessive jarring of the towed implement from being transmitted to the tractor itself.

HOW ONE MAN SPRAYS ACRES OF TREES IN AN HOUR

Insects are responsible for an enormous amount of damage in orchards, and not so long ago the only way to protect the fruit was to walk round with a hand pump and spray the trees with insecticide. This was a very slow business and was expensive of labour. With the machine illustrated above, it is possible to spray several acres of orchard in an hour. The machine consists of a tractor, in front of which is mounted a large fan. The insecticide, carried in a tank trailer, is pumped to a trough behind the fan, and as the vehicle moves forward the fan revolves. The blades then suck the insecticide from the trough and throw it outwards by centrifugal force.

BOAT THAT FIGHTS FIRES AT 40 MILES AN HOUR

On the right you see a fire-fighting boat used by the Royal Air Force for rescuing the crews of blazing aircraft that fall into the sea. The boat is 46 feet long and is driven by two 357-horse-power engines which give it a maximum speed of 40 miles an hour, and it can travel at that speed for five hours without refuelling. The hull is made of fireproof material so that the boat can travel through burning fuel or wreckage. The two fire-fighting nozzles, shown in action in the photograph, are fed by pumps delivering 500 gallons of water a minute. Rescue equipment includes line-throwing rockets, a powerful searchlight, a winch, and gear for towing heavy aircraft. The cabin is fitted out as a hospital for treating injured survivors of a crash. The fireboat carries a crew of five. In wartime the boat would be armed with machine-guns mounted in revolving turrets on the bow and stern.



A QUEER ANIMAL THAT BEHAVES LIKE A BIRD

The lite-story of the platypus, which is shown on this page, is an interesting and curious one. The creature is a water animal of Australia living in and near rivers. It is covered with glossy hair, with a layer of soft waterproof fur nearer the skin. It has a beak something like a duck's, with nostrils at the end. Its feet are webbed like a duck's for swimming, but the webs can be turned back when the claws are used for digging. The platypus is a good swimmer, and grubs at the bottom of the river for aquatic insects and small crustaceans, on which it lives. It collects these in its cheek pouches and then rises to eat them. It digs a burrow in the bank of the river with a chamber at the end, and there are two entrances, one into the water and one on to dry land. In the chamber the female makes a rough nest and lays one or more eggs. She then sits on them like a hen, and soon the young are hatched. When they break through the shell they are blind and naked, and are fed with milk by their mother. At this stage they have little cheek teeth, which soon disappear. A full-grown platypus is eighteen inches long. It has an oily smell and growls like a puppy. The animal sleeps in the daytime and goes out hunting at night. It floats upright in the water, when it looks something like a floating bottle. In its burrow it sleeps rolled up in a ball like a hedgehog. It also rolls up when frightened. In place of teeth the animal has its jaws furnished with horny plates, these having a sharp edge in front which breadens out at the back of the beak

QUAINT LITTLE MAMMALS THAT LAY EGGS

We naturally think of a bird as laying eggs, and most of us know that many of the reptiles and amphibians do the same. We may have come across a clutch of grass snake's eggs in a heap of manure, and perhaps we have been shown a crocodile's egg. But we do not think of mammals, the highest type of animals that feed their young on milk, as being egg-layers. Yet there are such, and here we read about them

In one sense all young animals, whether they be mammals, birds or insects, come from an egg, but in the mammal the young is produced alive instead of being hatched after the laying of an egg.

There are, however, two kinds of mammals that actually lay eggs, and incubate them just as a hen or a blue tit sits on its eggs and hatches them out. These two strange mammals are exclusively Australasian, one of them, the platypus or duck-bill, being found only in Southern or Eastern Australia and Tasmania, while the other, the echidna or spiny ant-eater, of which there are two species, is found in Australia, Tasmania and New Guinea.

The more interesting of the two egg-laying mammals is the platypus. It is a strange-looking creature, eighteen or twenty inches long, and has a bill like a duck's, hence its popular name, and it has webbed claws also something like a duck's enabling it to swim easily. The front feet are bigger than the back ones and look as if they were two sizes too large for the little animal. Scientists call it the ornithorhynchus, a name made up from two Greek words, meaning a bird and a beak.

It is a water animal and spends its time in and near the rivers. The loose skin is thickly covered with glossy hair, and under this is a layer of soft waterproof fur.

The duck-bill has one great advantage, that while it has webbed feet the webs can be turned back and the sharp claws used for digging. The animal is a great digger, and it burrows into the banks of the rivers making a long, winding channel that leads to a small chamber. There are always two exits from the tunnel, one being under water and one above. No doubt this is not merely to give easy access to the duck-bill's home, but to enable it to escape should an enemy enter the burrow.

In the little chamber which it has dug out underground, the duck-bill makes a rough nest of grass, and there lays one or two eggs. It places its body on them as a hen does on hers to keep them warm, and in due course two little duck- ls are hatched out breaking the sh of the eggs to escape. These are not at all like their mother or father. When they come out of the egg they are blind and naked and their mother feeds them with milk

At first they have tiny cheek teeth, but these soon drop out and then in each jaw there develops a pair of horny plates which serves the purpose of teeth. There is a sharp edge in front, and this broadens out at the back.

The duck-bill's food consists of water insects, crustaceans and worms, and it finds these by grubbing with its beak in the river mud and sand. As it kills the food this is stowed away in capacious cheek pouches and afterwards eaten at leisure.

The platypus or duck-bil' rarely leaves the water, except to enter its burrow. It swims rapidly by means of the large front paws, but it is seldom seen by day, for it sleeps during the daylight, and those who wish to see the animal in its native haunts must go out at night, taking a light. It has a queer way of floating with its bill upright out of the water, and when there are several duck-bills floating in this way it looks for all the world as though a number of bottles are floating with their necks out of the water.

When in its burrow the duck-bill sleeps rolled up in a ball, something like a hedgehog, and it also rolls itself

The echidna or spiny ant-eater, so called because with its long flexible tongue it can seize ants for food. It often rolls up like a hedgehog when danger threatens, but if there is time it prefers to bury itself in the ground. It lays eggs and incubates them

up in this way if it is alarmed. Curiously enough it lives on friendly terms with the water-rat that inhabits the same river bank. The young very soon learn to swim, and both old and young animals are able to remain for quite a long time under water should they fear the presence of an enemy But the duck-bill is not quite defenceless. On its heels the male has strong horny spurs and a little canal which opens at the point is connected at the base with a duct from a venom gland in the back of the thigh. The spur can be used as a nasty poison weapon. The duck-bill's nostrils are situated at the end of its bill.

When travellers first came home and told of this strange animal, men of science thought they were merely telling " travellers' tales " and did not believe them. But gradually their story became known, and now we know the habits of the creature fairly well.

The Royal Society sent a special representative all the way to Australia to study the animal, and it was largely owing to his researches that we know the truth about the duck-bill.

The platypus has been kept in captivity, although to do so is not easy. A naturalist caught an adult female and her two young ones, and he found that during the day the mother remained very quiet, huddling up with her young ones, but at night she became restless and seemed eager to escape.

The little ones were as frolicsome as puppies. The duck-bills loved a bath in a shallow pan placed in a corner, but they did not care for deep water. They seldom remained in the water more than ten or fifteen minutes at a time.

They slept a great deal, and it was curious that of the two young ones, one often slept while the other was running about. The animals could climb easily to the top of a bookcase. They lived on bread soaked in water, chopped eggs and minced meat.

A Hedgehog-Like Animal

The other egg-laying mammal, the spiny ant-eater, whose scientific name is echidna, is a small creature, fifteen to eighteen inches long, and unlike the platypus, its nose is drawn into a long, slender snout covered with a moist, black membrane, like a dog's nose. It has no teeth, and the back is covered with stiff, sharp spines like those of the hedgehog mixed with long, coarse hairs. It also, when danger threatens, curls up like a hedgehog, and thus protects its under parts which have no spines, but are covered with silky brown hair.

The male echidna has spurs on its heels, but is never seen to use them. It lives in burrows and feeds on ants which are captured by means of the long, slender tongue that is thrown out and catches the ants very much as though it were a flypaper.

It is not a water animal like the platypus, but is generally found in the mountains and its broad fore-feet have enormously powerful claws with which it is able to dig quite easily.

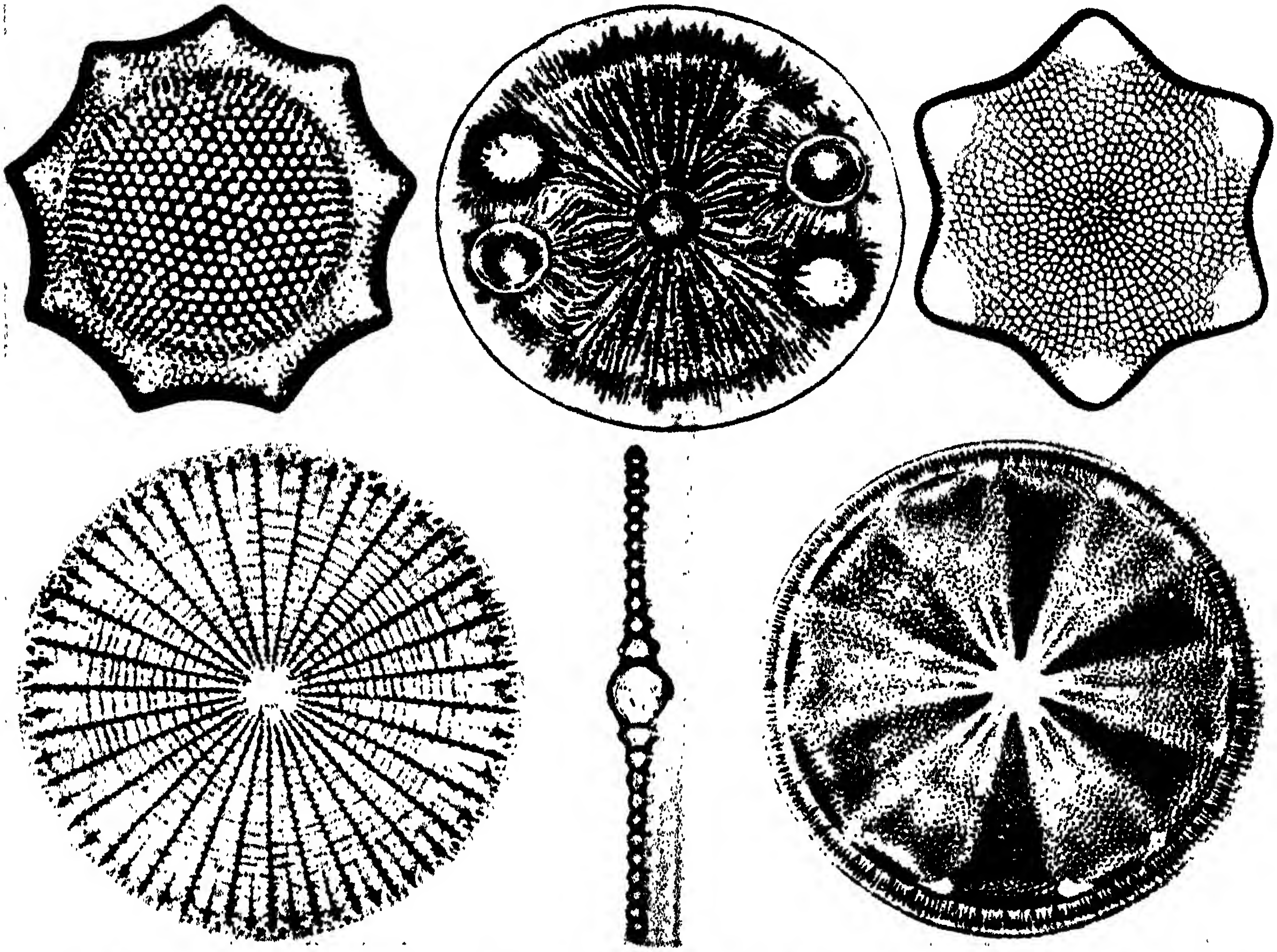
When the breeding season comes the female echidna develops a nursing pouch on the under-side of the body, and in this is deposited a single egg. It places the egg in the pouch by means of its snout. The egg is thus kept warm by the mother's body, and as soon as it is ready to hatch the young animal inside breaks the shell by means of a knob at the back of its muzzle. It goes on living in the mother's pouch until it is grown to a certain size, and then the mother takes it out, but from time to time it returns to the pouch in order to obtain milk from its mother.

These egg-laying mammals are very interesting, because they form a kind of link between the reptiles and the mammals. They are representatives of some half reptilian mammal ancestor of the past

ANIMAL FOOTPRINTS MADE MILLIONS OF YEARS AGO

When a slab of sandstone from the Grand Canyon of the Colorado was split open the footprints of an extinct amphibian were clearly marked, as can be seen in this photograph, which is given by courtesy of the United States National Museum and the Carnegie Institution of Washington. It shows the positive and negative surfaces of the sandstone when the block was split open and the two halves separated. The tracks are as clear as when they were first made

PLANTS FROM THE SEA'S DRIFTING MEADOWS



There is a regular chain of food in the sea, each creature preying on something smaller than itself. At one end of the scale we have the giant whales, and at the other end the tiny diatoms, the most numerous of all the drifting plants of the sea. Each diatom secretes a protective covering of fine silica, which falls to the bottom of the sea when the plant dies, and thus great deposits of silica are formed, which when raised up above sea-level provide huge supplies of diatomaceous earth, for which man has found many uses. Over 8,000 species of diatoms have been discovered, and there is hardly a geometrical shape that is not represented among them. In this photograph, given by courtesy of Dr. Albert Mann of the Carnegie Institute of Washington, the diatoms are magnified about 350 diameters

In these photographs, reproduced by courtesy of the United States Bureau of Fisheries, we see a certain species of copepod, which is the most numerous of all the animals that feed upon the plankton plants, such as diatoms. Plankton means "wandering," and is a reference to the drifting of the minute plant forms. In the left-hand photograph the copepods are magnified about two diameters, and we get some idea of their immense numbers. On the right they are magnified about nine diameters

THE NUT THAT IS THE STONE OF A PLUM-LIKE FRUIT

We can buy almond nuts either shelled or in their shells. As a matter of fact the shell with the kernel inside is really the stone of a stone fruit, like the plum or greengage, but it is a curious fruit, for the flesh dries up into a leathery husk, which cracks open and frees the stone inside.

Instead of throwing away the stone of the almond, as we do that of the plum and greengage and peach, we use it, and a very delicious and enjoyable nut it provides.

There are two kinds of almonds, the sweet and the bitter The latter yields a flavouring extract which is much used in cookery and in the making of perfumes. Its kernels are ground and mixed with water, and from this mixture an oil is distilled which contains hydrocyanic acid. That is a poison, and has to be extracted before the oil can be used.

The sweet almond is grown in large quantities and is a cultivated form of the wild almond of the Mediterranean countries. The tree has a beautiful flower like that of the peach, and is grown a great deal as an ornamental plant. The shells of the almond easily discolour, and for the market are often bleached, so as to look a bright yellow and thus attract a more ready sale

An almond branch loaded with ripe nuts after the flesh has dried up

THE POTATO'S ROMANCE

The potato seems a commonplace vegetable, but its story is quite a romance. It is one of our principal articles of food, and many of the Irish live almost entirely upon it.

Yet it is a near relative of our deadly nightshade, the most poisonous plant to be found growing in the British Isles. The leaves and fruit of the potato itself are poisonous, but the tubers, or swollen parts of the underground stems, which we call potatoes, are full of starch, and provide a vegetable food that is more useful than any other except bread.

The potato has been a good friend of Ireland, for before the introduction of the plant that country often suffered from famine. When in 1846 the potato crop failed, the people of Ireland suffered severely as a result.

Yet although the potato is of tremendous value all over Europe to-day, it was only introduced from the Andes of Chile and Peru, where it grows wild, after the Spanish invasion of the sixteenth century.

It was introduced to Ireland in 1586, and was first planted on Sir Walter Raleigh's estate at Youghal in County Cork. It became a useful food in that country for some years before it was known in England.

The story is told that Sir Walter Raleigh presented the new vegetable to Queen Elizabeth, and the plant was grown in the Royal kitchen gardens, the green leaves being gathered and set before Her Majesty in the form of a salad. The taste made Elizabeth suspicious, and Sir Walter was sent for and charged with trying to poison the Queen. It is said that he saved himself from execution by explaining that it was the tubers alone which were fit to eat.

Poisonous Seed-Cases

Children are sometimes poisoned through eating the green balls that enclose the seeds. Potatoes are not grown from the seeds, but from the tubers, which are cut up into sections, each containing an eye. From the eye a new plant springs, and many tubers then form underground, provided the soil is suitable. It must be rich and deep, and contain sufficient sand to insure proper drainage. Potatoes must not be grown two years in succession on the same plot of ground.

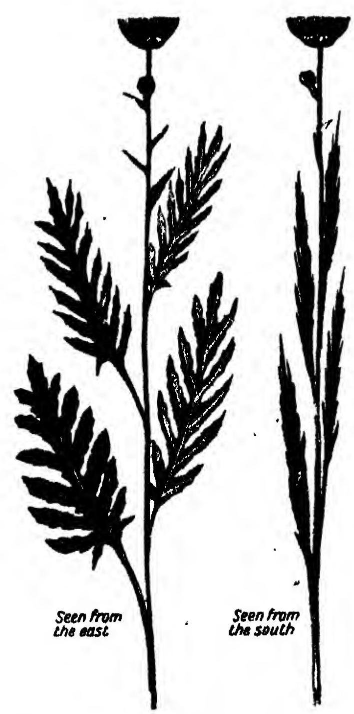
Anyone interested in plant breeding can create new varieties of potatoes or improve the old ones by taking a little trouble. Some horticulturists devote themselves to the raising of potatoes from seed, and it is from their experiments that the best new varieties come into existence.

Alcohol is obtained from potatoes, and starch for the making of a substitute for cornflour.

A potato plant growing from an old tuber

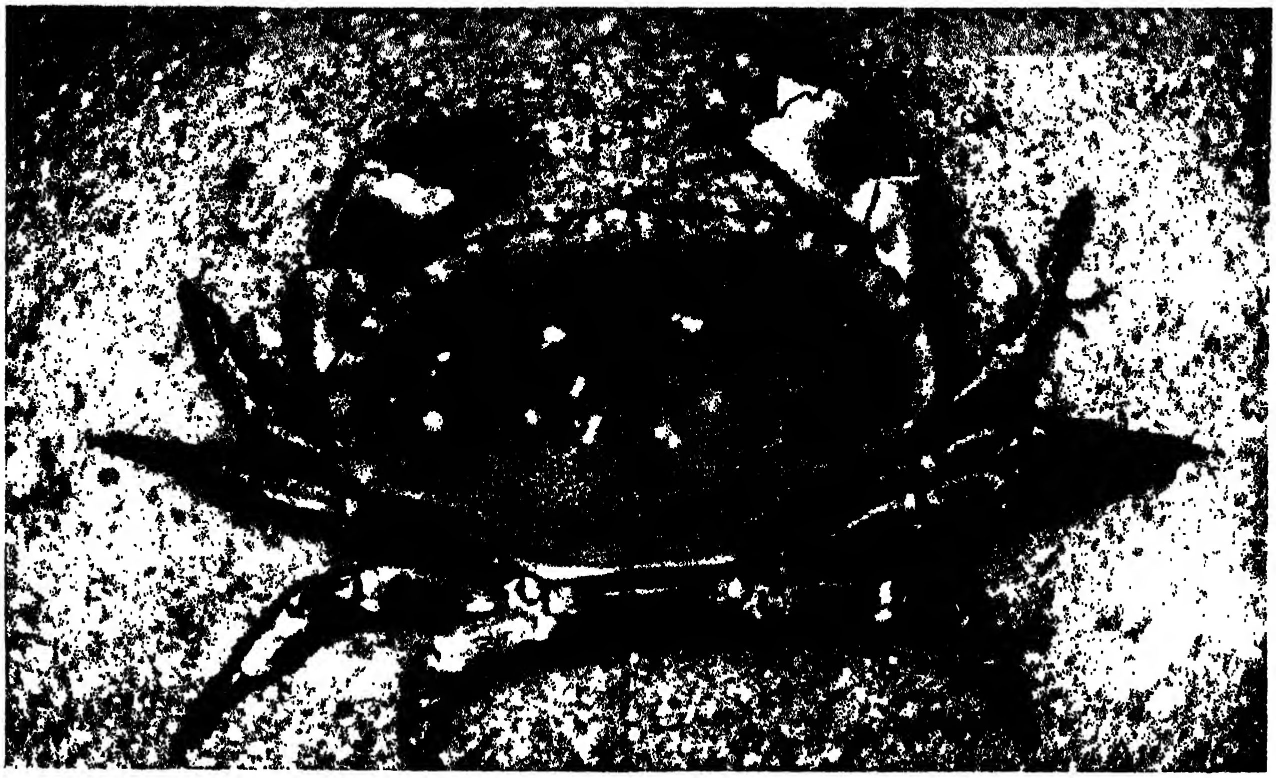
THE COMPASS PLANT

The silphium, a North American shrub, is called the compass plant because it is flattened as though pressed, and the broad surfaces of the leaves always face east and west, that is, in the direction of the rising and setting sun. Travellers can obtain their bearings by looking at it.

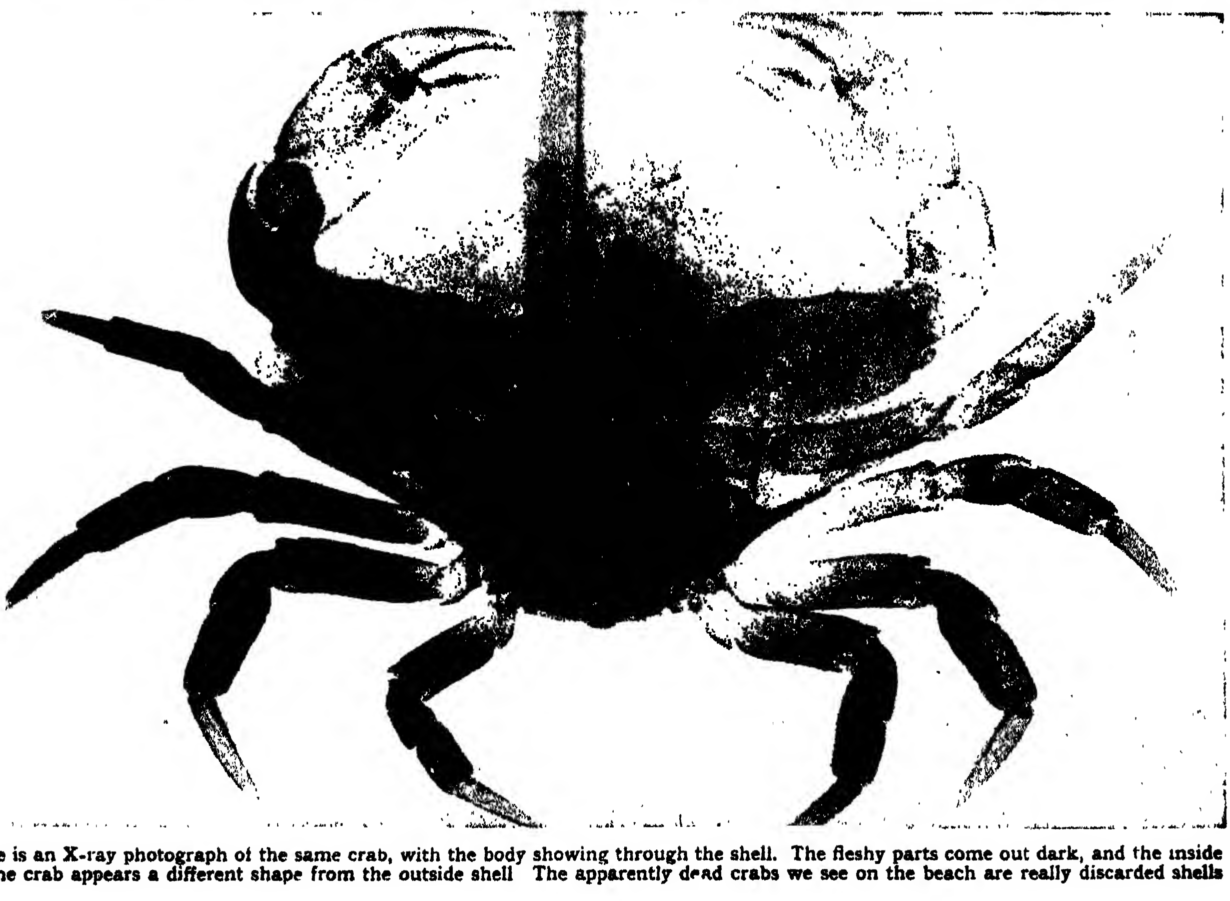


Silphium seen from two points of the compass

THE INSIDE AND OUTSIDE OF THE EDIBLE CRAB

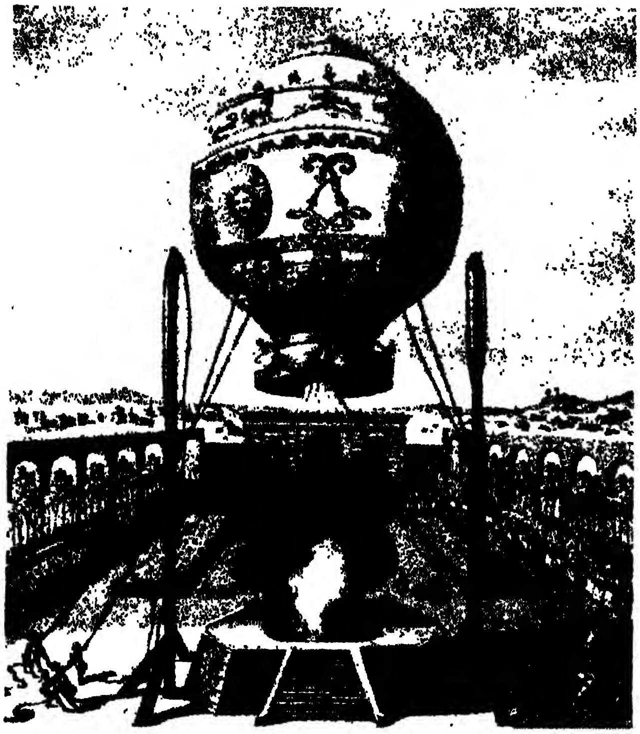


This photograph shows an edible crab on the sand The carapace is quite hard and prevents the crab growing like ourselves. Once year it bursts the shell open and crawls out, a soft creature, and then begins to grow a new suit of clothes of a larger size



Here is an X-ray photograph of the same crab, with the body showing through the shell. The fleshy parts come out dark, and the inside of the crab appears a different shape from the outside shell The apparently dead crabs we see on the beach are really discarded shells

EXPLORING THE FRONTIERS OF SPACE



The drawing on the left shows the scene outside Paris on November 21, 1783, at the start of the world's first free balloon flight. The balloon was kept aloft through the continuous heating, and therefore expansion, of the air inside the varnished silk envelope by means of a fire of chopped straw carried in a brazier under the balloon. The balloon, which was piloted by Pilatre de Rozier, rose to a height of 500 feet and travelled a distance of five miles in 20 minutes. To the onlookers, de Rozier's balloon ascent was a breathtaking achievement and caused considerably more excitement than did the ascent to 120,000 feet (just over 19 miles) on August 20, 1957, by Major David Simons, a U.S. Air Force doctor

1. Major Simons seated in his balloon gondola receives congratulations from Captain Joseph Kittinger, who a few days previously had ascended to a height of 96,000 feet. Although the aluminium gondola was only 7 feet high and 3 feet across, it carried, besides the balloonist, a mass of instruments for measuring cosmic radiation and other conditions beyond the earth's atmosphere. 3. The 280-feet long balloon beginning its ascent from the bottom of an ironstone quarry. As the balloon rose, the helium gas with which it was inflated expanded and gave it the ordinary balloon shape. 4. Now several thousand feet up, the balloon's plastic envelope begins to expand

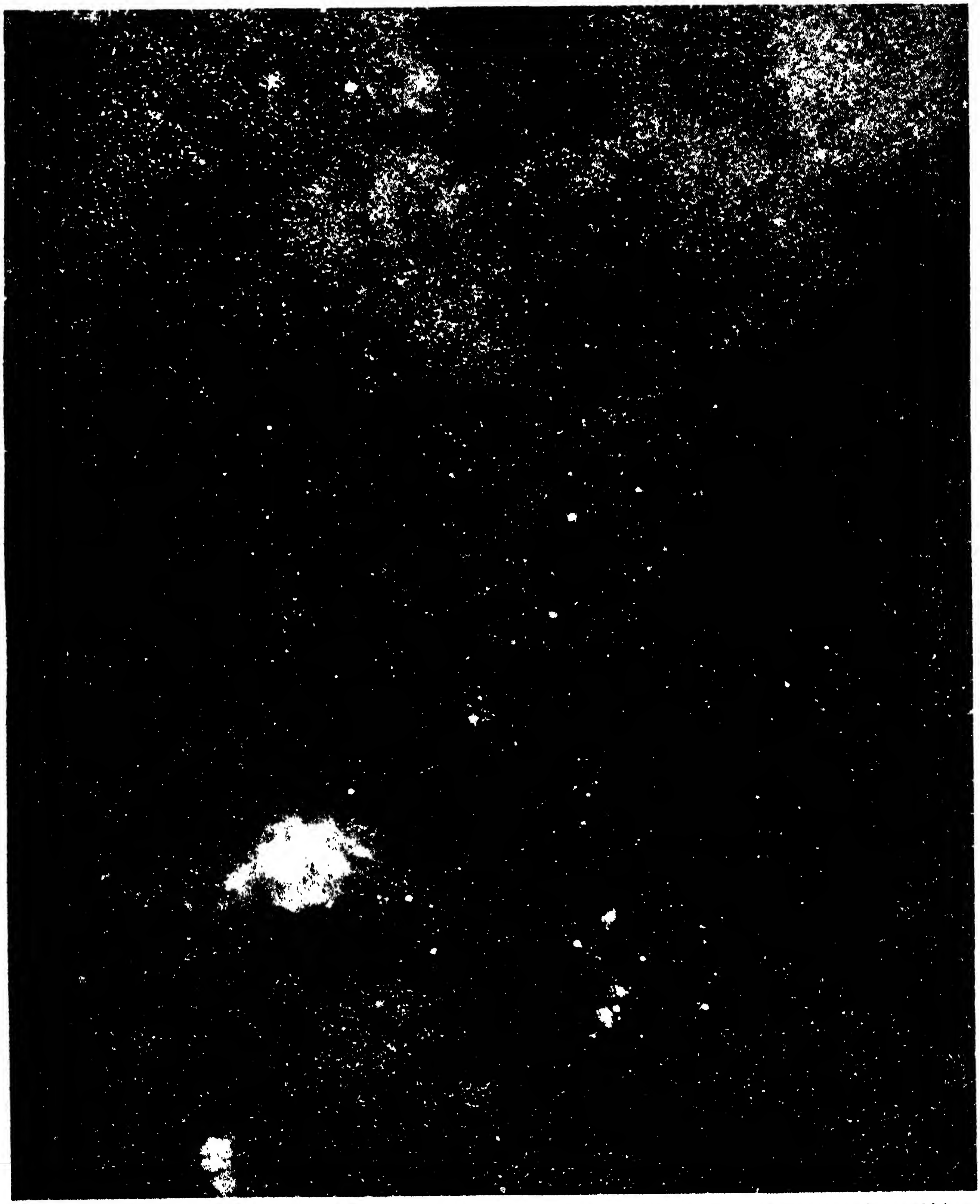
2. The beginning of a balloon ascent on November 11, 1935, when captains Albert Stevens and Orvil Anderson of the U.S. army reached a height of 72,395 feet (over 13 miles)

THE BITTER ENEMIES OF THE SNAKES

It is not only man that regards the snake as an enemy, but some, also, of the animals and birds. Here we see a Mexican bird, the road-runner, fighting a rattlesnake The road-runner never hesitates to attack a snake when it sees one, striking with its sharp beak and then jumping aside like lightning to avoid the venomous jaws of the reptile. The bird is almost invariably the victor

Even in England the snakes have their bitter enemies among the animals, and one of these is the hedgehog. The animal, in attacking an adder, rolls itself up, then uncurls and bites the snake, curling up again and repeating the operation till the back of the snake is broken. It next passes the whole body of the reptile successively through its jaws, cracking it and breaking its bones at intervals of half an inch or more. It then eats the snake, beginning always at the tail end

A SMALL PORTION OF THE MILKY WAY



Small is a relative term. A pea is small compared with a football, and a football a mere speck compared with the globe on which we live. When, therefore, this photograph is said to show a small portion of the Milky Way, the expression is true so far as the whole Galaxy, of which our solar system forms a part, is concerned. But the area shown in the photograph really covers thousands of millions of miles, and every dot is a sun as big as or bigger than our own Sun. This portion of the Milky Way is seen in the direction of the constellation Sagittarius, and it shows a particularly dense part known as a star cloud, where the stars appear very close together compared with other parts. This photograph is reproduced here by courtesy of the Carnegie Institution of Washington

IF WE PASSED THROUGH A DARK NEBULA

In the vastness of Space there is to be seen every here and there a black patch which looks as though the sky were empty. But it is believed that these patches are dark nebulæ, huge masses of very fine dust, which shut off the light of stars beyond them. Some scientists think that in its passage through Space the solar system might encounter one of these great dust clouds, and the possible results of such an encounter are discussed here

The Earth, with the whole solar system, is travelling through Space at about twelve miles per second towards the region where the star Vega now is. It will take us about half a million years to reach that place, and then Vega will not be there, for it also is moving on.

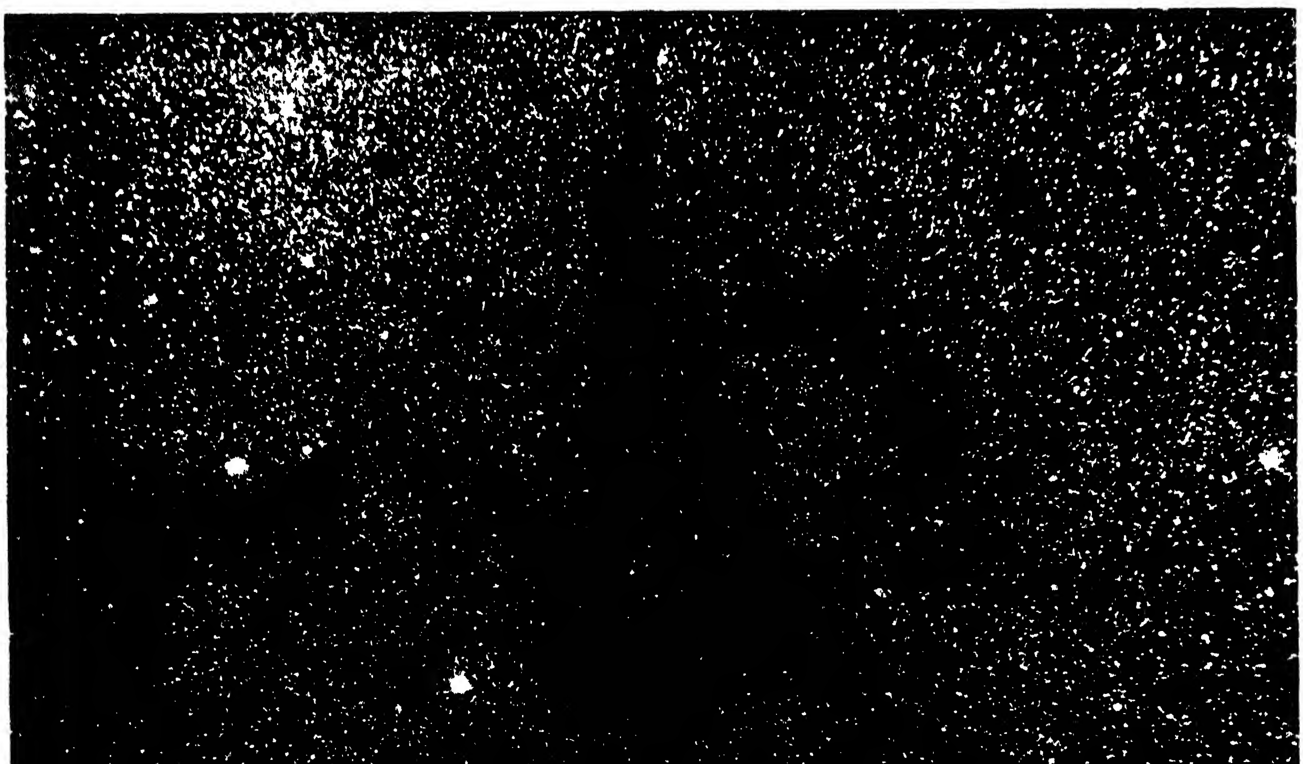
But in our journey during that half-million years are we likely to meet anything else on the way? There is little chance that we shall ever collide with a star. The stars are a great deal too far apart in Space for such a collision to be likely. Astronomers have reckoned that if the average star were the size of an orange, the stars would be distributed so sparsely in Space that none would be nearer to another than 3,000 miles.

We can gather from this how remote is the likelihood of a collision. In fact, astronomers tell us that celestial collisions occur only about once in a thousand million million years.

But there is another possibility which is not so remote. Scattered about in Space are great masses of cosmic dust, and it is not an impossibility that as our system journeys through Space we may meet and pass through one of these vast dust clouds. The nearest of them is very far off at the present time, and such an encounter is only likely to happen, if at all, thousands or perhaps million of years from now.

Some geologists believe that the solar system has actually travelled through these vast clouds of cosmic dust in the past. It is believed that the last time was about a million years ago; and it is suggested as the cause of the Great Ice Age, which began about that time. The shutting off of much of the Sun's heat by the cosmic dust is supposed to have reduced the temperature and brought about the Ice Age.

On the other hand, there are some scientists who think that contact with one of these cosmic fogs might make the Earth more habitable than it is at present, for the cloud might contain some unknown element or gas which would help to prolong life.

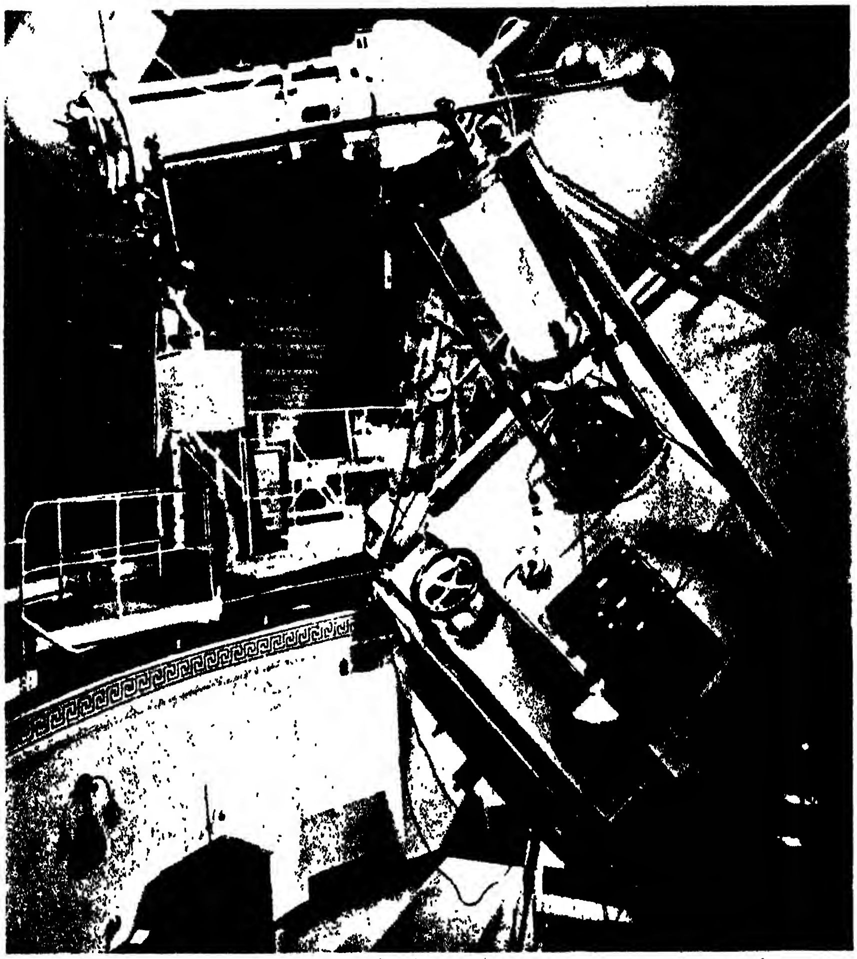


A nebula, to be seen in the constellation Ophiucus, showing dark patches believed to be masses of cosmic dust. The photograph was taken with the 100-inch telescope at Mount Wilson Observatory, and is reproduced here by courtesy of the Observatory

HOW WE CAN UNDERSTAND THE STARS

The spectroscope that tells us not only what the distant stars are made of, but whether they are moving towards us or away from us, is in its simplest form a prism, and how it works is explained on pages 450 to 452

But in actual practice when the stars are being examined by means of a spectroscope, the apparatus used is by no means simple. It is a combination of a big telescope, a complicated spectroscope with many prisms, and an elaborate camera. The big telescope catches the light of the star and passes it on to the spectroscope, which analyses the light and enables the camera to make a photograph of the spectrum Then the astronomers can examine this spectrum at their leisure and read in it the story of the star.



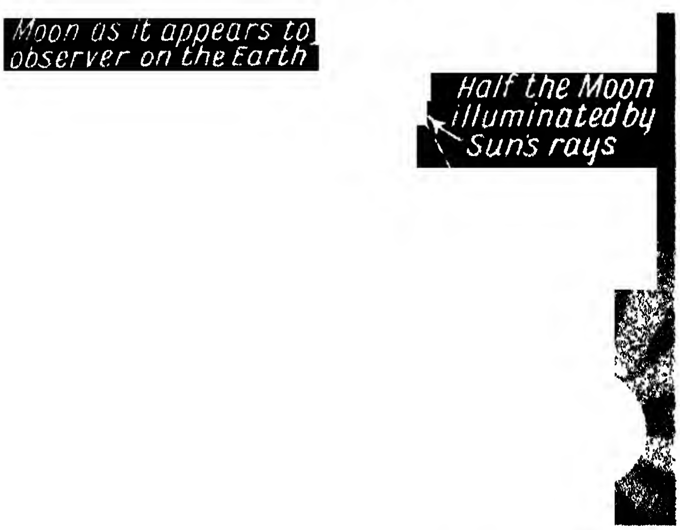
The spectrograph is an elaborate combination of the telescope, spectroscope and camera. This photograph shows a large spectrograph installed in an observatory.

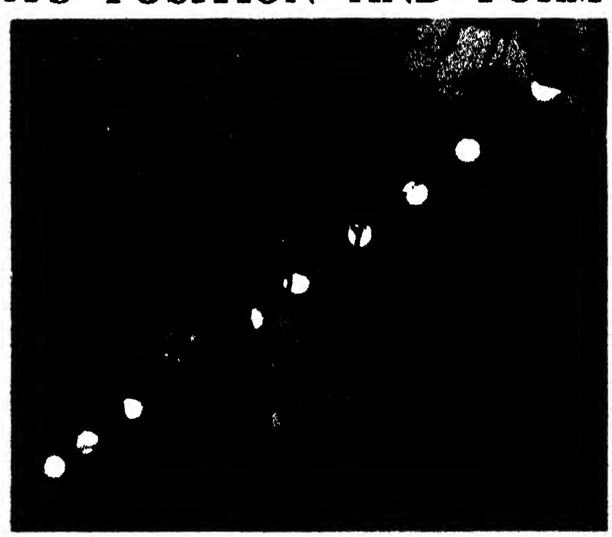
The combined apparatus is known as a spectrograph, and an example of the instrument as used in large observatories is shown on the left.

The spectrograph is rightly regarded as one of the greatest achievements of modern science. When it catches and analyses the ray of light from a star that is scores of light-years away, it unfolds the secret of that star's composition, tells us whether it is in a gaseous or solid state, whether it is highly heated or comparatively cool, whether it is a new star or one far advanced in evolution, and both the amount and the direction of its motion. We know whether the star is expanding and becoming hotter, or whether it is cooling down and becoming more dense.

It is an amazing instrument.

HOW THE MOON CHANGES ITS POSITION AND FORM





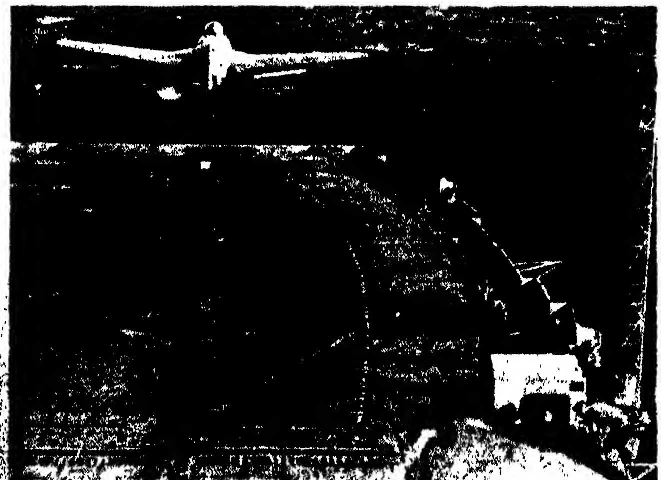
The picture-diagram on the left shows why the Moon does not always appear to us as a bright disc. The Sun is not drawn to scale. Of course, the half of the Moon upon which the Sun shines is always completely illuminated, but when Sun and Moon are in the relative positions shown with regard to ourselves, we cannot see the whole of the Moon's hemisphere which is lighted up, but only part of it, and so it appears to us as half a disc. Other positions make the bright part of the Moon appear to us as less than half a disc, or more than half. This is explained in detail on page 478. The Moon moves across the sky with considerable speed, as can be seen in the photograph on the right. On this plate exposures were made about every ten minutes, and we can see the progress made by the Moon and how, with the motion of the Earth, it seems to ascend as it goes

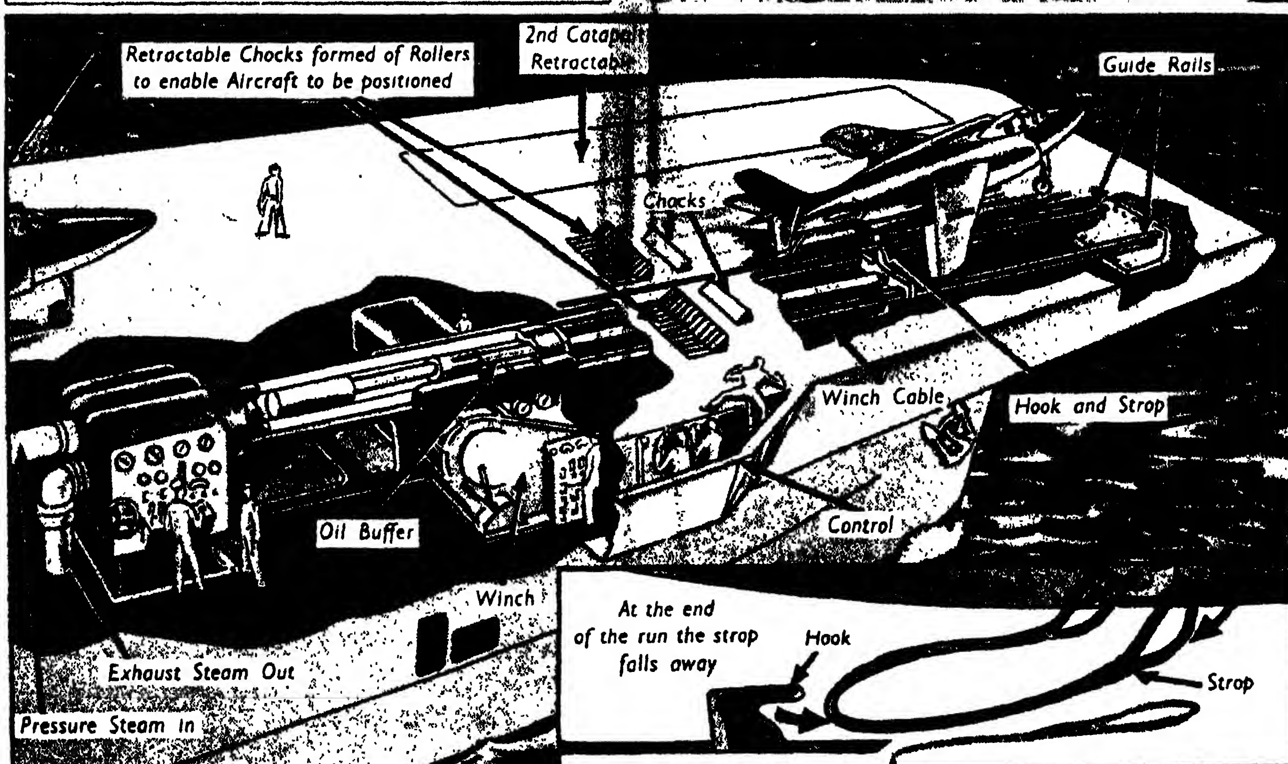
CATAPULTING AIRCRAFT WITH STEAM

When an aircraft takes off under its own power from a carrier, the ship must be turned so that its bows are into the wind, while the aeroplane must have a clear run for the full length of the flight deck. This system has the great disadvantage that the number of aircraft that can be put into the air in a given time is limited, and aircraft cannot take off if the carrier is stationary. Accordingly the Royal Navy introduced the steam catapult in 1956. The drawing below shows how the device works. The aircraft to be launched is positioned by means of rollers over a slot in the bows. Below the slot is a piston moving in a cylinder supplied with steam from the ship's engines. The aircraft is then attached to the front of the piston by a hook and strop which is fixed to the bottom of the undercarriage. The pilot takes his place in the cockpit, and, after he has started up his engine, signals that he is ready to take off. Steam at high pressure is then released into the cylinder and forces forward the piston and the aircraft attached to it. When the piston reaches the end of the slot, the hook is disengaged from the aircraft, which is then shot over the bow and becomes airborne. The carrier has two catapults, one on either side of the bow, and when not in use they are retracted flush with the deck. By using the steam catapult it is possible to launch a squadron of twelve aircraft in a matter of six minutes.

The steam catapult has been adopted by the United States Navy and is used for launching the Matador guided missile. This consists of an unmanned, rocket-propelled aircraft which can be loaded either with high-explosives or an atom or hydrogen bomb. Matadors are brought by lift from a magazine adjacent to the catapult and can be mounted automatically on to the launcher. The whole procedure of launching, starting up the Matador, and releasing it from the catapult is done by remote control, so that the carrier crew is not exposed to radiation should the ship itself be under atomic attack. When the Matador is airborne, it is guided towards its target by radio-control and its course can be followed on a radar screen.

Above (right) an Attacker is forced by steam catapult along the flight deck of H.M.S. Eagle, and (left) another aircraft is positioned over the catapult slot. Below, a Sea Hawk becomes airborne at the moment of disengagement from the steam catapult.





COASTAL ROCKS SMASHED UP BY THE SEA

The sea is never still, and all round our coasts it is busy at work. Generally it is breaking up the coastline, except at those places which are protected by sea walls or breakwaters built by human agency. At other places the sea is building up the shore by piling up on the beach the fragments of rock that have been broken away from other parts of the coast. In addition, at many places the land itself is being upheaved slowly so that the sea recedes more and more. In this photograph of the Pulpit Rock, taken at Portland Bill, in Dorset, we can see how efficiently the sea does its work of smashing up the rocks. It is aided by frost and rain, the water which gets into the cracks being frozen in severe weather, and forcing the rock apart. When a particularly heavy sea dashes against the rock, as when a fierce gale is blowing, heavy masses like that shown leaning against the Pulpit Rock are hurled down, and soon get broken up into smaller fragments. The inclined block leaning against the isolated pillar gives the illusion of a staircase leading up to the pulpit

HOW THE FLASHING LIGHTNING COMES

Lightning may be caused in several ways, as by a volcanic eruption or a dust storm. But the most frequent cause is the heat storm in which the atmosphere becomes a huge electrical generator, rising air and falling rain interacting and causing the lightning. Here is the latest knowledge about lightning

MEN of science are always studying the phenomenon of the lightning and are constantly finding out new facts about it.

It was thought until quite recently that the clouds in a thunderstorm were charged with electricity, the top part with positive and the lower part with negative electricity, and that the air was an insulator. When the charges became powerful enough to break down the insulating effect of the air it was believed they leapt over the gap as a spark, and that spark was the lightning.

The most recent researches, however, suggest that this theory is incorrect. Scientists now believe that the clouds are perfect electrical insulators and that the air is a slight electrical conductor.

The electricity of the lightning is energy and the energy must come from somewhere. What is its source? Mr. John F. Shipley, who is an authority on the subject, points out that the initial energy is provided by the Sun's radiation, which evaporates water from the sea and from damp and forest areas.

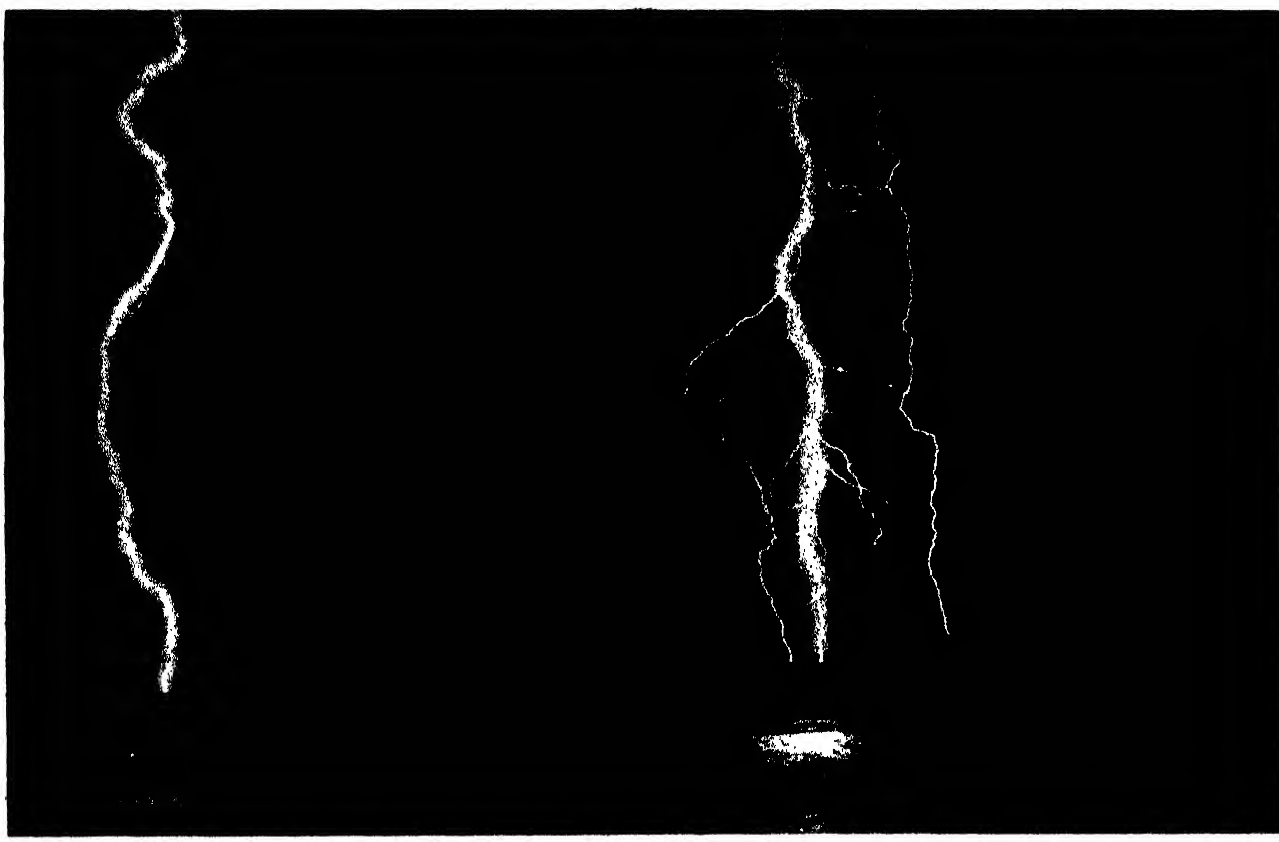
The warm air containing moisture rises and condenses and eventually forms the towering cumulo-nimbus cloud of the thunderstorm.

The clouds may often be seen forming at the sea's surface and ten minutes after the warm, moist air rises in columns, while another ten minutes sees the cloud rapidly expanding. "The transfer of energy in such a cloud formation," explains Mr. Shipley, "is on an immense scale. For instance a cumulo-nimbus cloud, about three miles in diameter and rising three miles, might easily be lifting 200,000 tons of water, and if it took an hour the horse-power used in that lift alone would be about 180,000"

Thunderstorms are often associated with plateaux and hills, for a wind blowing against these will cause an upward vortex. Such a change of direction of the wind always gives rise to a good deal of turbulence and may easily be the starting-point of a thunderstorm.

The warm, moist wind pours into the rising column and what goes on there has been described by aeronauts. The aircraft is raised and dropped violently again and again and bombarded with rain and hail, while the noise of the warring elements is terrific. It was such a storm that the great American airship *Akron* ran into, and before long it was driven down to the sea and wrecked.

When the moisture-laden air reaches the cold upper regions, the water vapour is condensed into drops and its energy is released. The drops then



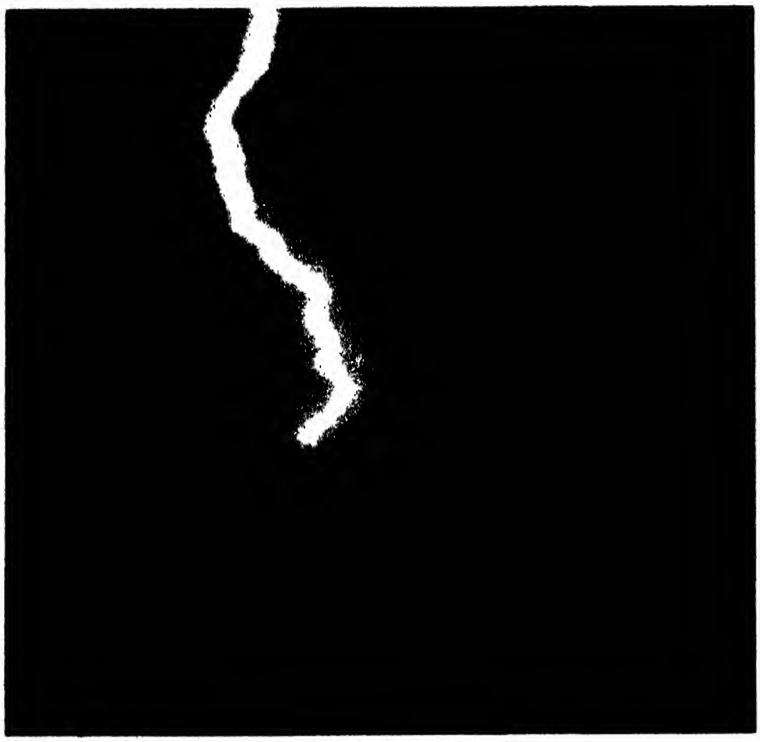
A remarkable photograph of lightning passing almost perpendicularly from the clouds to the Earth, at Elizabeth Castle, Jersey, in the Channel Islands. The flash on the right has many branches, and in form is very similar to a fibrous root in the soil. The principle of movement in both cases is the same. There are slight irregularities in both the soil and the air, and just as the fibres of the growing root follow these in the one case, so the flow of the electric current follows the irregularities in the air

begin to fall but as they come down they meet the vortex of rising air which carries them up again. This results in the big rain drops being broken up and electrified, but as they are carried up the fact that they are electrified causes them to unite again and down they fall once more. The operation is repeated and Mr. Shipley helps us to understand what happens.

"Each time a drop is shattered," he says, "its droplets become positively electrified while the corresponding negative charge is carried off by the air. This process is cumulative and very soon the electrical difference of potential between the two separated portions of electricity becomes very intense. When the stress between the positive and negative portions thus separated reaches about 75,000 volts an inch a small portion of the intervening air becomes so hot that it becomes a small conductor and gets hotter still, owing to the current flowing in it.

"The mass of positive electricity is held by raindrops, but the negative portion is held by the molecules of air and these negative discharges of electricity gradually become distributed throughout the cloud mass by the turbulent conditions which have already been described. This negative electrification may, therefore, reach such an intensity that a breakdown may occur to earth."

In tropical regions accumulations of electricity often discharge to each other in the tops of very high clouds. Sheet lightning is sometimes the flood-lighting of the clouds by a succession of these flashes.

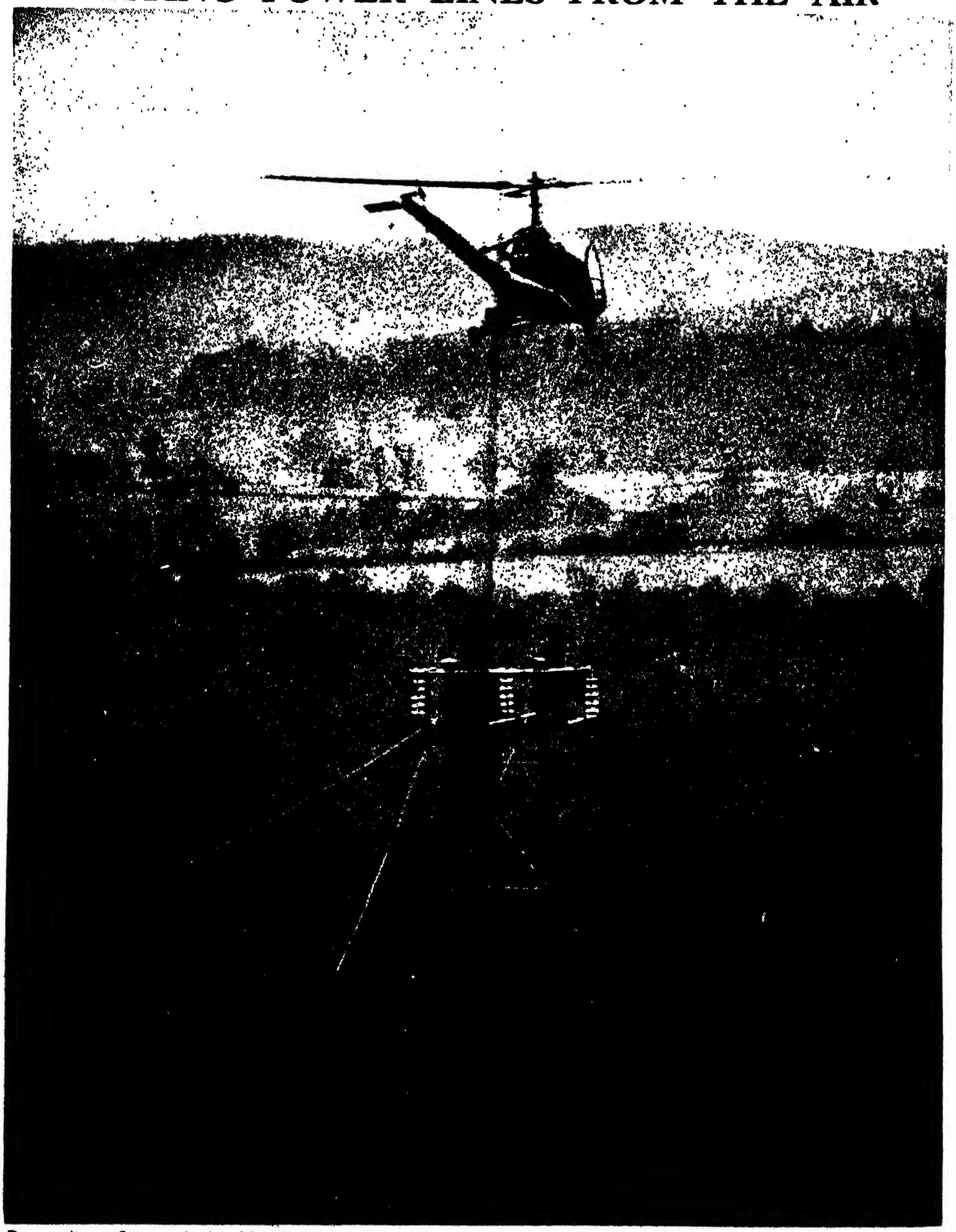


A photograph showing the great Empire State Building in New York, the tallest building in the world, with lightning playing about its summit. No damage was done to the building. Being built of steel it is in itself a good conductor

A RIVER OF ICE BECOMES A RIVER OF WATER

This photograph shows the torrent of water issuing from the end of the Grindelwald glacier in Switzerland, where the ice is melting. It is as though a long block of ice were pushed towards a hot stove melting as fast as it arrived. The glacier is moving forward all the time, but the end remains at nearly the same point. It is not quite stationary, however, but retreats or advances with changes of the season

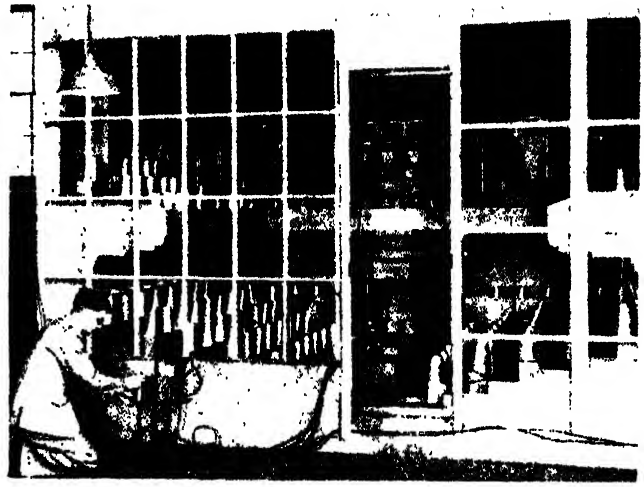
LAYING POWER LINES FROM THE AIR



Because it can fly very slowly with safety and even remain hovering above the ground, the helicopter is one of the most useful of "working" aircraft. Here we see the helicopter which was used in 1952 to lay a 1,250-ft. power cable across a densely-wooded valley on the Herefordshire side of the Malvern Hills, England. In the ordinary way, much time and labour would have been spent in cutting down hundreds of trees and in making paths, but with the helicopter the actual paying-out of the cable was done in five minutes, and engaged only eight men. The drawing on pages 1368 and 1369 explains how a helicopter is flown.

EVERYDAY WORK AT THE NATIONAL PHYSICAL LABORATORY

Screws are checked for accuracy by comparing an enlarged projection of the thread with a template.



A technician using a scale model of the House of Commons to test the ventilation of that building.

This equipment is used for measuring the sound-absorbing qualities of different materials.

The " dock " in the ship tank, showing models waiting to be tested by instruments on the travelling carriage.

This building houses the laboratories and workshops of the Physics Division of the National Physical Laboratory at Teddington, Middlesex

WHERE THEORY IS PUT INTO PRACTICE

LESS than a mile from Hampton Court Palace, Middlesex, and near the famous Chestnut Grove, is Bushey House. This characteristic Georgian building, once the home of William IV, hardly suggests the latest developments in applied science. But historic Bushey House is the headquarters of the National Physical Laboratory at Teddington, where scientists and engineers now carry out research programmes to solve a host of industrial problems.

Queen Victoria presented Bushey House to the Royal Society in 1900 as headquarters for the then recently formed National Physical Laboratory which in 1918 became part of the Department of Scientific and Industrial Research.

To-day the National Physical Laboratory has a staff of over 600 experts in all branches of scientific and technical knowledge who work in a score of buildings spread over 23 acres of ground. The fundamental purpose of the laboratory is to break down the barrier between theory and practice and to effect a union between science and commerce.

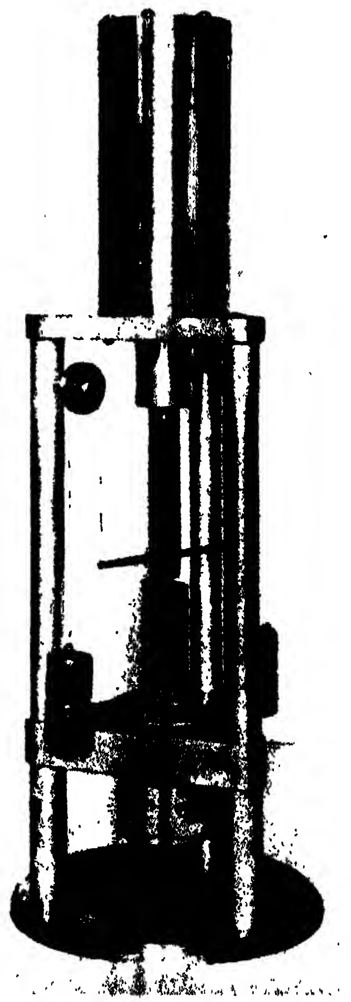
Guarantee of Accuracy

Although the National Physical Laboratory's initials on an article are the scientific guarantee of the maker's claims for its accuracy, the layman seldom hears of the work at Bushey House; yet upon it depends the safety, stability and efficiency of hundreds of everyday things. Ask technicians anywhere in the British Commonwealth the meaning of the initials N.P.L. on chronometers, capacitors (condensers), wave-meters, or any other measuring instrument, and you will be told: "Without those initials, precision and experimental work would be impossible."

The work of the laboratory is spread over eleven main departments or divisions: Aerodynamics, Electricity, Engineering, Light, Mathematics, Metallurgy, Metrology, Physics, Radio, and Ship. Each division is in charge of a scientist specially qualified in his subject and under him he has a staff of technicians and engineers.

Metrology is the scientific name for measuring, and in the Metrology Division accuracy is a cult to which the staff devote their working lives. They do not reckon precision in thousandths, but are satisfied only when they achieve accuracy to millionths of a degree. This exactitude controls all standards relating to mass, length, time, area, volume, density and pressure.

One of the chief concerns of the Metrology Division is to carry out the periodical comparisons of the British Standards of length and mass for the Board of Trade. This ensures, for example, that when you buy a pound of sugar in one grocer's shop it should weigh the same as a pound of sugar bought in another grocer's shop. Similarly, the standard yard measure in the Metrology Division makes it possible for the law to insist that a yard of cloth bought at one draper shall be exactly the same length as a yard of cloth purchased at another draper.



This instrument is called a cavity resonator and is used at the National Physical Laboratory to measure the speed of light.

The standard yardstick is a length of specially alloyed metal, but as it shrinks and expands with changes in temperature, it is not always the same length. Accordingly, the National Physical Laboratory is experimenting with a device that uses the wavelength of light, which never alters, to fix an absolutely constant standard of length.

Watchmakers send their watches and clocks to be tested at the Metrology Division, as do the manufacturers of measuring glasses for medicine. The reason why engineers can always be sure that when they buy screws to fit certain sized holes the screws will be the right fit is because the Metrology Division has a machine for testing standard screw gauges which can deal with screws up to ten feet long.

For very fine engineering and scientific work it is sometimes necessary to draw extremely thin lines. To do this the Metrology Division has a machine that can rule nearly 30,000 lines within a space of one inch.

Without accurate surveyor's tapes for measuring land it would be impossible to produce the plans used when laying out the foundations of new roads or buildings. Every surveying tape used in Great Britain is tested in the Metrology Division to an accuracy of one part in a million.

Ships' chronometers, upon which depend accurate navigation at sea, are sent to Teddington to have their time-keeping accuracy tested. The examination lasts 60 days: ten in a temperature of 70°; ten in a tropical heat of 100°, ten in a refrigerator at 40°; and another ten days at a temperature of 70°. The chronometer then spends the remainder of its stay at the laboratory having its time-keeping carefully compared with a standard clock.

Testing Thermometers

When the doctor takes your temperature he knows that the temperature registered must be correct, for his thermometer had its accuracy tested in the Physics Division of the National Physical Laboratory. Every month the Division tests 40,000 clinical thermometers by lowering them into electrically-heated baths and then checking the reading of each with a master thermometer.

In the radiology section of the Physics Division are delicate instruments for measuring the strength of radiation from radio-active materials. These instruments have established a basis of calibrating X-ray dosimeters used to govern the strength of X-ray treatment in medical cases. The radiology section also tests the protective value of materials used in X-ray installations, and measures the safety limits of radiation that can be received by operators working with X-rays and other radio-active substances.

Another section of the Physics Division has instruments able to measure the strength and loudness of noise, and the staff draw up and put into practice methods of reducing noise and its effects. A fully equipped mobile noise-laboratory is maintained for measuring sound transmission and its absorption in buildings and factories anywhere in Britain.

Measuring colours is also one of the activities of the Physics Division. With the help of an elaborate type of spectrum it is possible to separate

shades of colours into their primaries, and so judge the proportion of tints in any particular shade. A colour key has been compiled as a series of numbers, so making easier the problems of paint manufacturers, who now have at their disposal specifications for 57 standard colours. That is why when you ask a decorator to paint a room apple green, for example, he can buy apple green paint at two or three different shops, in the knowledge that the paint from each should always be of the same colour.

The Light Division of the National Physical Laboratory is responsible for the fact that when you purchase an electric lamp marked at 60 candle-power, it will give a light equal to that of 60 candles when switched on.

Proper lighting is of the greatest importance in the everyday life of the community, and the Light Division is constantly trying to improve the methods of illuminating factories, offices, art galleries, coal mines, streets and docks. Other work of the Division is concerned with the design and improvement of ships, navigation lights, traffic lights, and railway signalling lights. Other tasks undertaken by the Division include the determination of the candle-power of electric and gas lamps, motor-car headlights, red reflectors for bicycles, etc. All these are tested to make sure that they meet legal requirements.

Optic Section

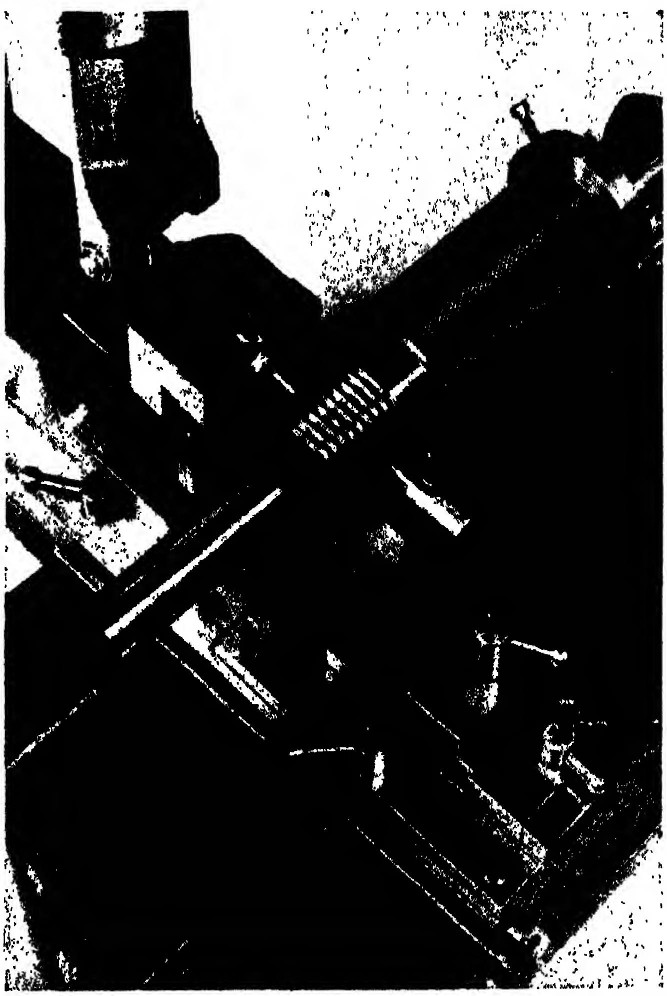
In the optic section of the Light Division are carried out tests of all classes of optical instruments, such as telescopes, binoculars, sextants, theodolites, and photographic lenses and shutters.

One of the most important departments of the National Physical Laboratory is the Electricity Division, which fixes and maintains the British legal standards: the ampere, the volt and the ohm. In addition to these primary standards, called the C.G.S. units because they are based on the centimetre, gramme and second units of length, weight and time, the Division maintains the standard measures of capacitance and inductance.

Electrical measuring instruments such as voltmeters, ammeters, wattmeters, and equipment such as fuses and lightning conductors are tested in the Electricity Division's laboratories.

In the Division's high-voltage research laboratory is a transformer that can produce an electric spark of 1,000,000 volts and a generator able to induce an electric current at a pressure of 2,000,000 volts. Another instrument, which has a screen like that of a television receiver, is used to give a moving graph of the effect of lightning discharges in the neighbourhood of power cables.

Researches into the physical and mechanical properties of metals and alloys, their constitution and structure is the principal function of the Metallurgy Division. This branch of research has many aspects and includes the systematic examination of the effects of heat and mechanical treatment on metals and alloys during their manufacture.



Engineers rely on this machine for the accuracy of the nuts they screw on to bolts. It checks the diameter and thread of the gauges used in the manufacture of the nuts.

Closely related to the work of the Metallurgy Division is that of the Engineering Division, for it carries out research into the reactions of metals when put to practical uses, as in the erection of bridges, steel-framed buildings, ships, locomotives, etc.

Research relating to the pressure of wind on structures is continuously carried out by the Engineering Division to provide details needed by engineers designing structures likely to be exposed to high winds. Three wind tunnels, which reproduce on a small scale, with models, the wind conditions likely to be encountered by the completed building are used by the laboratory.

Other tasks of the Engineering Division include experiments to decide the best streamlined shapes for motor vehicles and railway engines, and there are instruments for testing the efficiency of gears and of steam and internal-combustion engines. With a view to preventing accidents, the Division investigates the causes of failures of chains and other lifting tackle.

The Engineering laboratory also has an ingenious machine that tests steel springs until they break, and equipment for determining why machinery and structures sometimes collapse because of metal "fatigue."

Wind Tunnels

Aircraft manufacturers anxious to try out new developments in design have models of the proposed aeroplanes tested in one or other of the Aerodynamics Division's wind tunnels. There are fourteen of these tunnels of various sizes, and one of them is able to reproduce on a model aircraft the conditions encountered by an aircraft breaking through the sound barrier.

Instead of having the model aircraft moving through the air, a model is suspended from wires in the middle of the tunnel and wind blown against it. Twin propellers force down a stream of air through the tunnel so that it strikes against the model. By controlling the flow of air through a slotted screen, artificial gales and air eddies are reproduced to scale, and their effect in the model established by recording instruments which measure the tension of the wires supporting the model aircraft.

Much of the efficiency of your sound or television receiver is due to the work of the Radio Division, which also carries out research in radar. The articles on pages 340, 1208, and 1443 describe and illustrate the results of such research.

Automatic control devices, described and illustrated on pages 261, 1257, and 1259, are the concern of the Electronics Division.

The work of the Ship Division is explained and illustrated in pages 856–857.

THE INTRICATE NET OF CROSSING RAILS

Not the least wonderful part of a railway system is the crossing of the lines where many tracks meet. These crossovers are masterpieces of railway engineering, and passengers owe a great deal to the technical staffs for the safety and comfort in which they travel, crossing as described here many tracks without inconvenience

THE most costly part of a railway track to build and maintain is that which contains many switches and crossings. The switches are for the purpose of diverting a train from one line of rails to another, while the crossings permit trains to go across a number of rails.

It is when we see a great crossing like that shown in the photograph on this page that we realise to what marvellous perfection the railway system of the country has been brought. If the people who grumble on foggy mornings as they come into London or some other great city for their daily work, and are held up for a few minutes because of the mist, would think for a few moments of the complicated network of rails over which their train must pass, they would, instead of grumbling, be full of praise for the railwaymen who can land them safely at their platform.

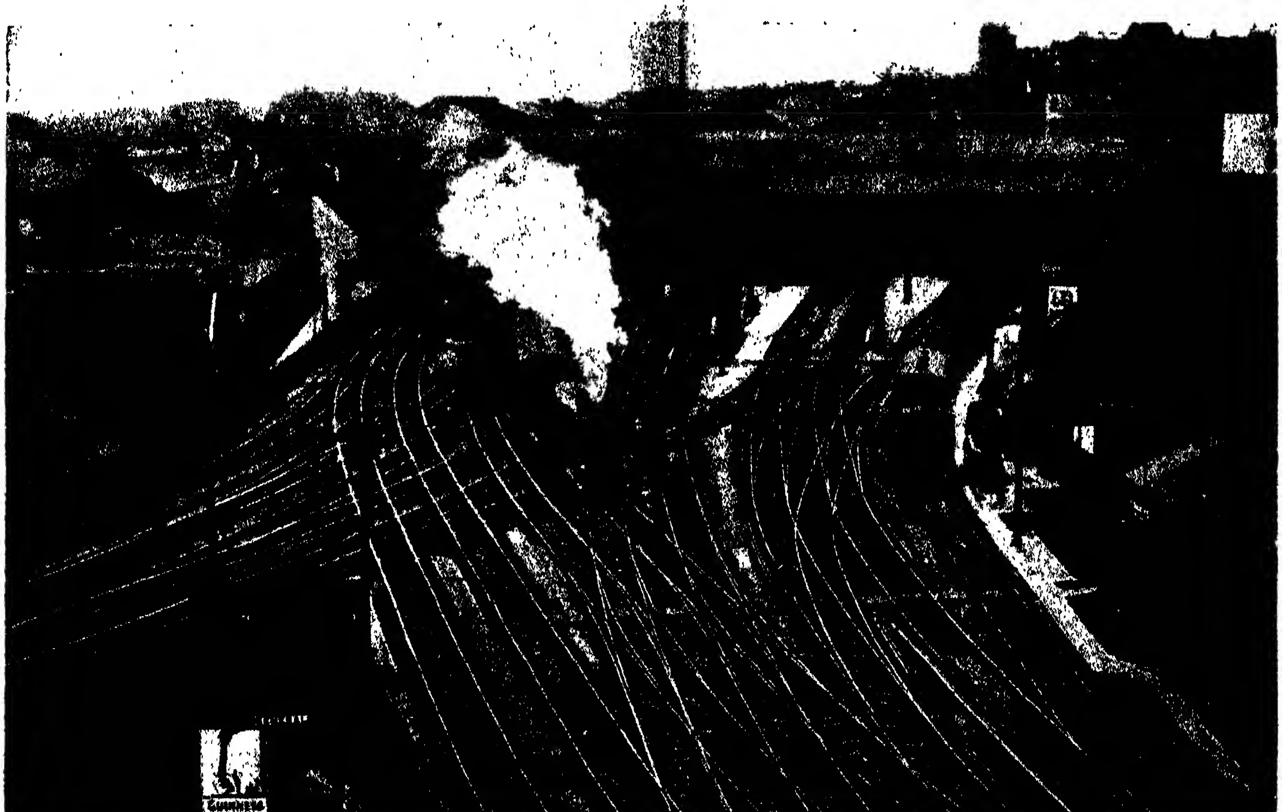
These crossings with the switches must be most carefully designed and carried out, so that the wheels of the trains may pass smoothly and easily across the lines. If the trains jumped and shook, as they might easily do with ill-arranged crossings, the passengers would soon cry out at the discomfort. But there is scarcely any more inconvenience in passing over a great crossing outside a terminus or at a junction than there is in travelling along a clear set of rails.

The problem in crossing is to allow of the free passage of the wheel flanges, for railway wheels are quite unlike those of ordinary vehicles running on the flat. To give free passage to the flanges it is necessary to leave a considerable gap between the rails over which the wheels travel. The wheel never has to jump across a space, for, owing to the width of the flanges, these are always supported on one rail or another.

Different names are given to the crossings, according to their particular form. Behind every switch there is what is known as an acute crossing, while another form called the obtuse crossing is used only in diamond crossings, where one track goes right across another.

By using movable diamonds—that is, diamond-shaped sections of rails—which can be shifted either way, so as to give an unbroken path for the wheels through the crossing, the comfort of the passengers is greatly enhanced. Many of the crossings are very complicated, but in all cases they work with smoothness.

It may not be known to all that every foot of the track of a British railway on which passenger trains run is examined daily by platelayers, who see that everything is in perfect order. It is this care which makes the English railways so free from accident. The track is divided up into sections, each in charge of a ganger with a body of platelayers.



One of the largest railway crossings in England. The photograph shows the maze of tracks outside the Central Station, Newcastle

THE GIANT CLOCK THAT EVERYONE HEARS

Big Ben does not look very big when seen from the pavement, but as it is high up in the great Clock Tower of the Houses of Parliament, which at its pinnacle towers 320 feet above the ground, it must be very large to be seen. As a matter of fact, Big Ben is one of the two or three largest clocks in Great Britain, and for a long time it was actually the biggest.

The four dials of Big Ben are each 23 feet in diameter, their centres being 180 feet from the ground. The figures are two feet long, and the minute spaces between the hours cover an area of one square foot.

The great bell on which the clock strikes the hours, and which like the clock itself is also called Big Ben, weighs 13½ tons, and the hammer that strikes it weighs 4 cwts. It was the bell itself that was first called Big Ben, after Sir Benjamin Hall, and later the name was given to the clock as well.

The four quarter bells in the clock tower weigh nearly 8 tons, but they are not equal, their weights being 3 tons 18 cwts., 1 ton 13 cwts., 1 ton 6 cwts., and 1 ton 1 cwt.

On pages 520 and 521 we see how the great clock works and rings Big Ben, and also how the sound is broadcast all over the world.

These pictures give us some idea of the size of Big Ben, both the clock and the bell. On the left we see part of one of the clock faces on one side of the tower, and on the right the great bell with the hammer that strikes out the hours. The human figures help us to understand the great sizes of the clock dial and the bell. The bell is cracked and there has often been talk of recasting it

The minute hands are 14 feet long, and weigh about 2 cwts. each. They are made of copper, and in the course of a year each minute hand travels a distance of a hundred miles, that is, a greater distance than from London to Coventry. The hour hands are nine feet long and are heavier than the minute hands.

The pendulum is 13 feet long, and its bob weighs 4 hundredweights. The weights of the clock are nearly 2½ tons, and it is not surprising that the winding in the old days of hand-winding was a very big job. Nowadays, Big Ben is wound by electric motor.

The chimes are set to these lines:

All through this hour Lord be my guide,
And by Thy power no foot shall slide

Big Ben is a wonderfully accurate clock. As the Astronomer Royal pointed out some time ago, during a year its time was checked on 288 days at Greenwich Observatory, and on only 21 days did its error reach more than one second. Such a record is unique for a great tower clock which is working continuously.

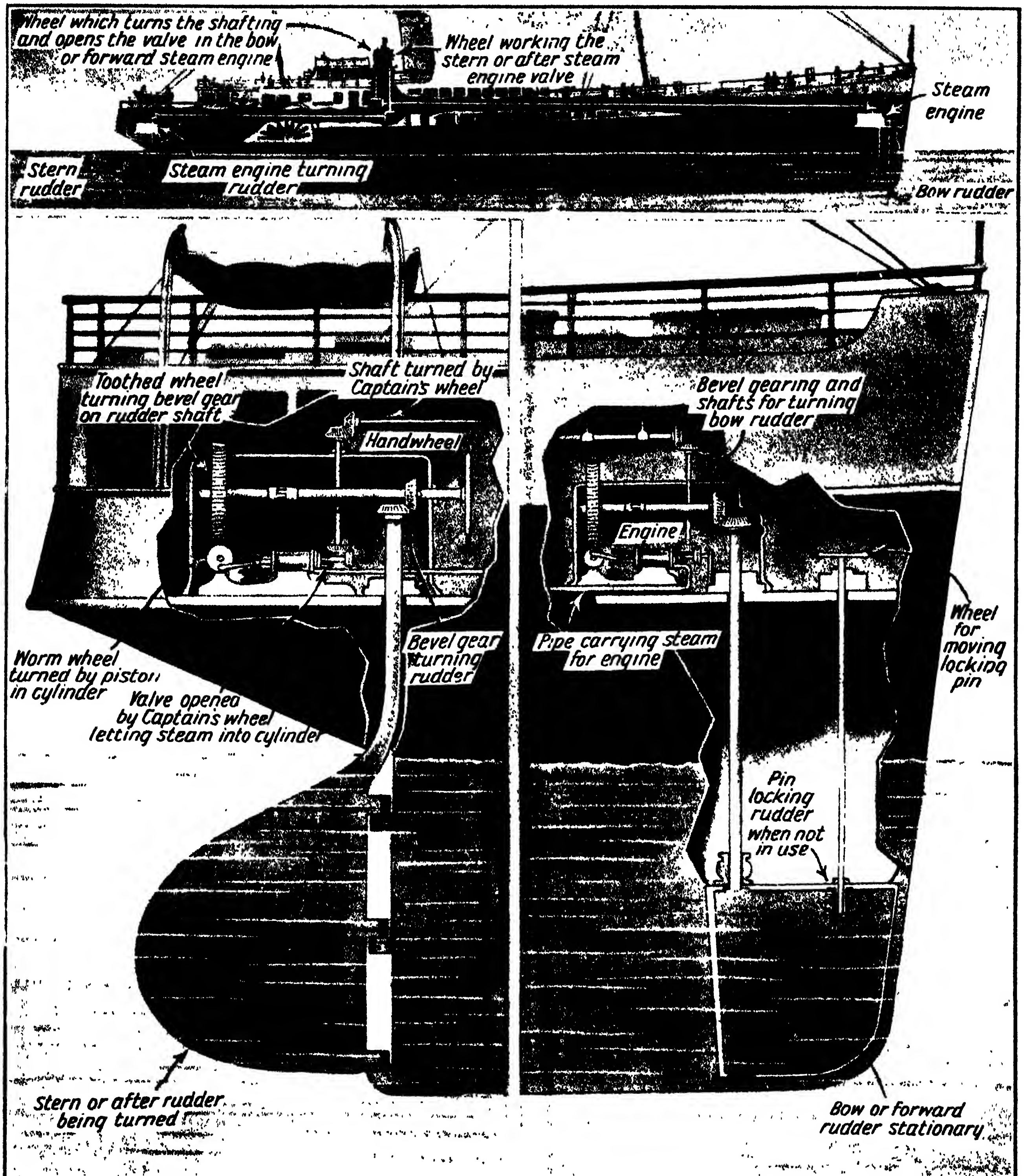
The Astronomer Royal explained how the error is kept so small. "A tray," he said "is fixed about half-way down the pendulum, and when the clock is losing slightly a halfpenny or penny is placed on the tray. This makes the pendulum vibrate slightly more quickly, and gradually brings the clock to time. If the clock is gaining a halfpenny or a penny is removed."

The first blow on Big Ben at each hour denotes the exact hour, and it takes a fifth of a second for the sound of the bell to reach the bottom of the tower, and two seconds for its note to reach Trafalgar Square.

Big Ben is not now the largest clock in England. The biggest clock in London is that on the Shell-Mex tower on the Embankment. Its face is 25 feet in diameter, but whereas Big Ben's hands are 14 feet and 9 feet, the new clock's hands measure only 11½ feet and 8¾ feet.

Two other big clocks are those of the Royal Liver Building in Liverpool, and the Singer Building on Clydebank. The former is 220 feet above the ground, has dials 25 feet in diameter, minute hands 14 feet long, and the weight of the four pairs of hands is 2 tons. The ironwork of the dials weighs 15 tons, and the glass 1 ton. The Singer clock is 26 feet in diameter.

A STEAMBOAT WITH A RUDDER AT EACH END

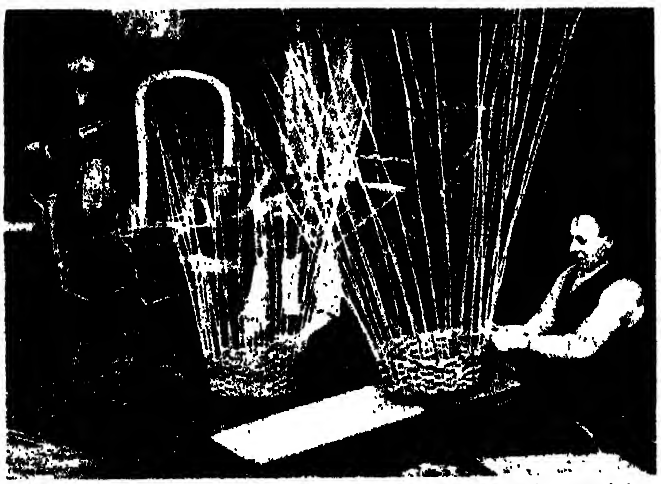


It is not generally known that the fine paddle steamers of the General Steam Navigation Company that carry passengers every day between London and such seaside places as Southend, Margate, Ramsgate, Clacton, and so on have a rudder at each end of the boat. They are known as bow and stern rudders, and each is operated by its own steam-engine controlled from the bridge by its own wheel. The reason for having two rudders is to facilitate movement in the Thames. At certain states of the tide the ships have to swing in the wide reach of the river off Blackwall and come up to London backwards for the rest of the way. By having two rudders the boat can be steered well and move rapidly in either direction. The bow rudder is used when the ship is going astern. In order to minimise mechanical risks direct coupling is used between the wheels on the bridge and the operating steam gear. The lower pictures show the two rudders with their operating gear and shafting, and the top picture shows how these rudders are worked from the bridge. It is important in narrow congested waters like the Thames that passenger vessels should thus be provided with the means to manœuvre with accuracy and ease, for any slight misjudgment on the part of the captain or pilot might lead to trouble with other vessels passing up or down. It must be remembered that though the Thames looks a fairly broad river, the actual channel available for ships using it in the passage to and from London is not very wide

TURNING THE OSIERS INTO BASKETS

Baskets are mostly made from a kind of willow called the osier, and the finest osiers are grown in England After being cut the willow rods, or withies, are soaked in water and then peeled

Next the peeled withies are placed in the sunshine to dry. They are, at this stage, called "buffs." Here we see them being collected after drying. They are then sorted according to size



First the bottom of the basket is woven together, and then upright rods are fixed firmly to it and thinner rods worked in and out as the worker in this picture is seen to be doing

Once the foundation has been laid, as shown in the previous picture, the rest is soon built up to the required height. On the right of this picture can be seen a number of finished baskets

At the top of the basket the ends of the upright rods are bent over to form an edge. This has a stout rim, so that it will not become frayed by wear and tear. The man on the left has just finished his basket. The making of a basket is a one man job

Basket-making can be done quite well by the blind, and here we see a blind worker finishing a clothes basket which he has made himself

THE GREAT WONDER OF A BIRD'S FLIGHT

Man has made remarkable strides in recent years in the conquest of the air, but the bird has been master of the air for hundreds of thousands and probably millions of years. Its mechanism for flight is wonderful, and far beyond the skill of man to imitate. It is not by copying the birds, however, that man has conquered the air, but by following quite a different principle, that of the straw hat which the wind lifts from your head and carries for a considerable distance. Here we read some interesting things about the flight of birds

It is by means of its feathers that a bird flies. It is interesting to note that when it is in flight the heavy organs within its body are kept well down, while the wings and lighter organs are situated much higher. In this way the centre of gravity is kept low, so that the bird, suspended in the air, is very much like a well-ballasted boat suspended in the water.

But the bird has wonderful control over its body, and when it shoots upward, plunges downward or turns, it does so by altering and adjusting rapidly the position of its centre of gravity. This is done in various ways - by expanding the wings, by moving the shoulder joints backward or forward, by movements of the tail, or by contracting or stretching its neck

The bird has more control over its flight than human beings have over their walking and running movements. Of course, in a heavy gale the wind may hurl a bird against an obstacle, just as it may blow a man over the edge of a cliff. In the ordinary way, however, a bird is never upset in flight.

The flight of a bird in the air is sometimes compared with the swimming of a human being in the water, but the analogy is not a good one. A human being in the water can float on his back, but no bird can fly or float in the air breast uppermost. The shape of its body and the position of its internal organs prevent this. A few birds, like the tumbler pigeon, can turn a back somersault in the air, but this movement has to be done very quickly.

All birds, of course, are heavier than air, and in order to start a flight a bird must exert great wing-power. If it were not heavier than air, it could not fly in the true sense; nor could birds of prey shoot down with lightning like rapidity upon their victims.

Some birds are very heavy in proportion to their size. The swan and the goose are examples of this. Yet these birds fly with a grace and speed that are astonishing. If we watch them rise from the water, their movement seems ponderous and difficult, but they soon get under way and then sail along gracefully

The movement of the wings is not merely an up-and-down motion. They are spread and folded and partly rotated, and they glide backwards and forwards as well, the whole motion compressing the air beneath the bird and helping to support it as it moves up or forward.

One of the most remarkable birds in flight is the little humming-bird. It is the tiniest of all birds, and yet in proportion to its size it has very long wings, and its muscles are exceedingly powerful. The action of the wings in flight is so amazingly rapid that it is quite impossible to follow them with the eye. They appear as mere misty films

Swans in flight. It will be noticed that their appearance in the air is very different from what it is on the ground or in the water.

HOW THE LADYBIRD ACTS AS THE FRIEND OF MAN

The ladybird, or as it is called in America, the ladybug, is a great friend of man, for it fights the insect enemies that prey upon the plants he cultivates.

We all know what a pest the aphis or greenfly is in an English garden; how the roses are spoilt by myriads of these tiny insects. Well, the ladybird hunts them and devours them in large numbers, and wherever ladybirds appear they should be treated as friends and allies.

While the familiar ladybird with its brightly-coloured wing-cases and spots eats the greenfly, it is really the larval stage of the insect that does most good. A picture is given on this page of the ladybird larvæ, so that those unfamiliar with it may know this friend when they see it on their rosebushes or elsewhere. Often people with no knowledge of insects think this larval ladybird is an enemy and they kill it. They are really doing an injury to themselves as gardeners.

There are several species of ladybirds in England, some with two spots, some with seven spots, and some with more. Some are red and some are yellow.

In California the ladybird is an even more useful ally of man in fighting the greenfly, which in that genial climate preys on all sorts of valuable plants.

It was known that the ladybird devoured the greenfly, but unfortunately the ladybirds in California appeared a month or two before the greenfly each year. The American scientists therefore set to work to think of some way by which they could bring the ladybird on the scene later than Nature arranged.

"If," said they, "we can find where the ladybirds hibernate and bring them away from their sleeping places to a cold building, we could keep them sleeping on through the early months of the year and wake them up about April, when the greenfly gets busy and multiplies. In this way the armies of ladybirds would begin their attack upon the greenfly just when those pests were massed for the assault on the fruit and other crops."

The larvæ of the ladybird which devour the greenfly enlarged slightly

Search was made, and with the aid of much patience and industry the hibernating haunts of the ladybirds were found up in the Rocky Mountains.

Now every year men are sent with mules up into the snow-clad mountains in winter. They gather the sleeping ladybirds by the million, pack them into sacks and bring them down on the mules, into the plains. There they are taken to a building known as the State Insectary and put into cold storage, so that instead of waking up in the early part of the year they will remain asleep till April or May.

Directly the scientists get information from the farmers and fruit-growers that the greenfly has appeared, they take the ladybirds, put them in a warm place to rouse them out of their sleep, and then divide them into batches of about 33,000, which they pack into boxes and send to the farmers.

The farmer is delighted to get his supply, and lets these allies loose in the orchards. The ladybirds have had no food for half a year, and having also overslept, are naturally more hungry than usual. The result is that they are very voracious and start devouring the greenfly at once.

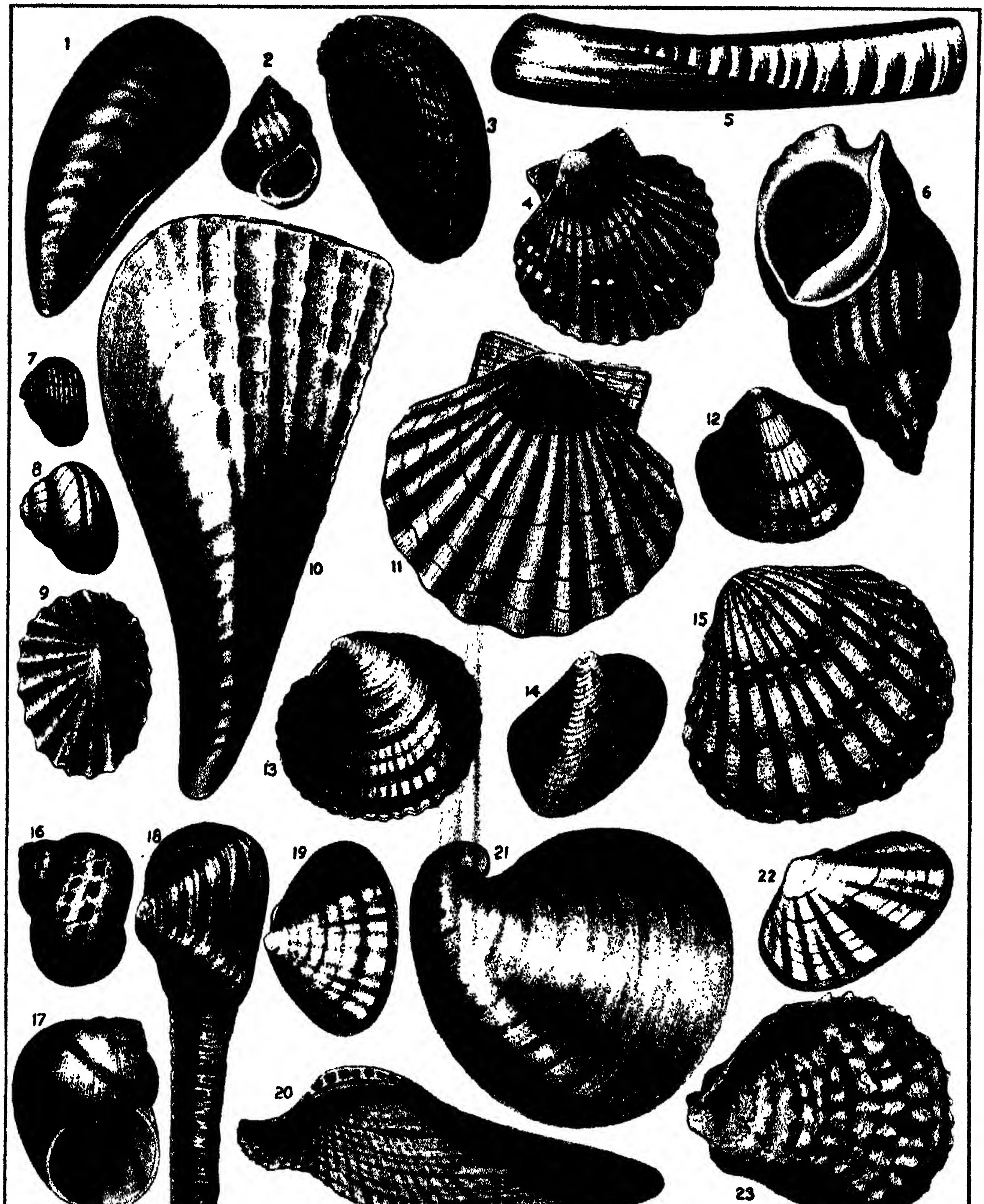
The experiment has proved a great success, and the collecting of the ladybirds has been going on winter by winter for twenty years or more.

The collectors start off early in November, and generally find the ladybirds among the pine needles on the well drained slopes close to running water. The work is of the utmost importance to the fruit-growing industry of California, and the holding back of the ladybirds for a month or two by putting them in cold storage has in the last twenty years saved hundreds of thousands of pounds to the fruit-growers and farmers.

In England it has always been dimly recognised that the ladybird or, as it is called in some parts of the country, the ladycow, is a friend. Popular rhymes and sayings regarding it refer to it in friendly terms.

An enlarged photograph showing a ladybird in the winged stage preying on the greenfly, or aphis, of which it devours large numbers

THE EDIBLE MOLLUSCS OF GREAT BRITAIN



Such molluscs as the oyster, mussel, scallop, cockle and whelk are common articles of food. But there are other edible molluscs and here are 23 British molluscs which form excellent foods: 1. Common Mussel. 2. Periwinkle. 3. Ear Shell or Sea Ear. 4. Painted Scallop. 5. Razor Shell. 6. Common Whelk. 7. Banded Snail. 8. Wood Snail. 9. Limpet. 10. Sea Wing. 11. Common Scallop. 12. Cockle. 13. Warty Venus. 14. Pullet. 15. Red-nose Cockle. 16. Common Snail. 17. The Apple, Vine or Roman Snail. 18. Gaper. 19. Trough Shell. 20. Piddock or Clam. 21. Heart Shell or Oxhorn Cockle. 22. Setting Sun. 23. Common Oyster

ANIMALS HEALTHY & HAPPY IN CAPTIVITY

Most animals can be as healthy in captivity as they are in the wild state. Indeed, such animals as the lion and tiger become much finer when they are well fed in a zoo than when they are living in their native state and have to hunt for their food. No wild lion has such a magnificent mane as the lions that are seen in zoological gardens, and certainly the coat of a wild tiger is never as fine as that of a properly kept captive one three fine cubs. No tigress had bred in the London Zoo for many years. At Whipsnade young animals are able to live in ideal natural surroundings, which make for their survival and healthy growth.

The upbringing of young animals is often a great problem for the zoo officials. Many years ago at the London Zoo a female hippopotamus gave birth to a baby, and as all did not seem to be going well with it the superintendent, Mr. A. D. Bartlett, decided to remove it from its mother, a task of some danger.

The female hippopotamus plunged into the water to attack the watering engine, and the keeper began to pump the water into her face. This caused her to dive, and so gave Mr. Bartlett time to escape with the baby.

As the little beast weighed nearly a hundredweight, and was as slippery and slimy as an eel, and further began to struggle with all its might, it was not an easy task to pick it up and carry it off quickly.

A tigress at Whipsnade and her litter of three healthy young cubs enjoying a sun-bath in the open-air of their home.

Great improvements in the housing of wild animals in captivity have been brought about in the last half century. It was Carl Hagenbeck, the German naturalist, who, with his famous zoo at Hamburg in the early 20th century, led the way in the proper keeping of wild animals.

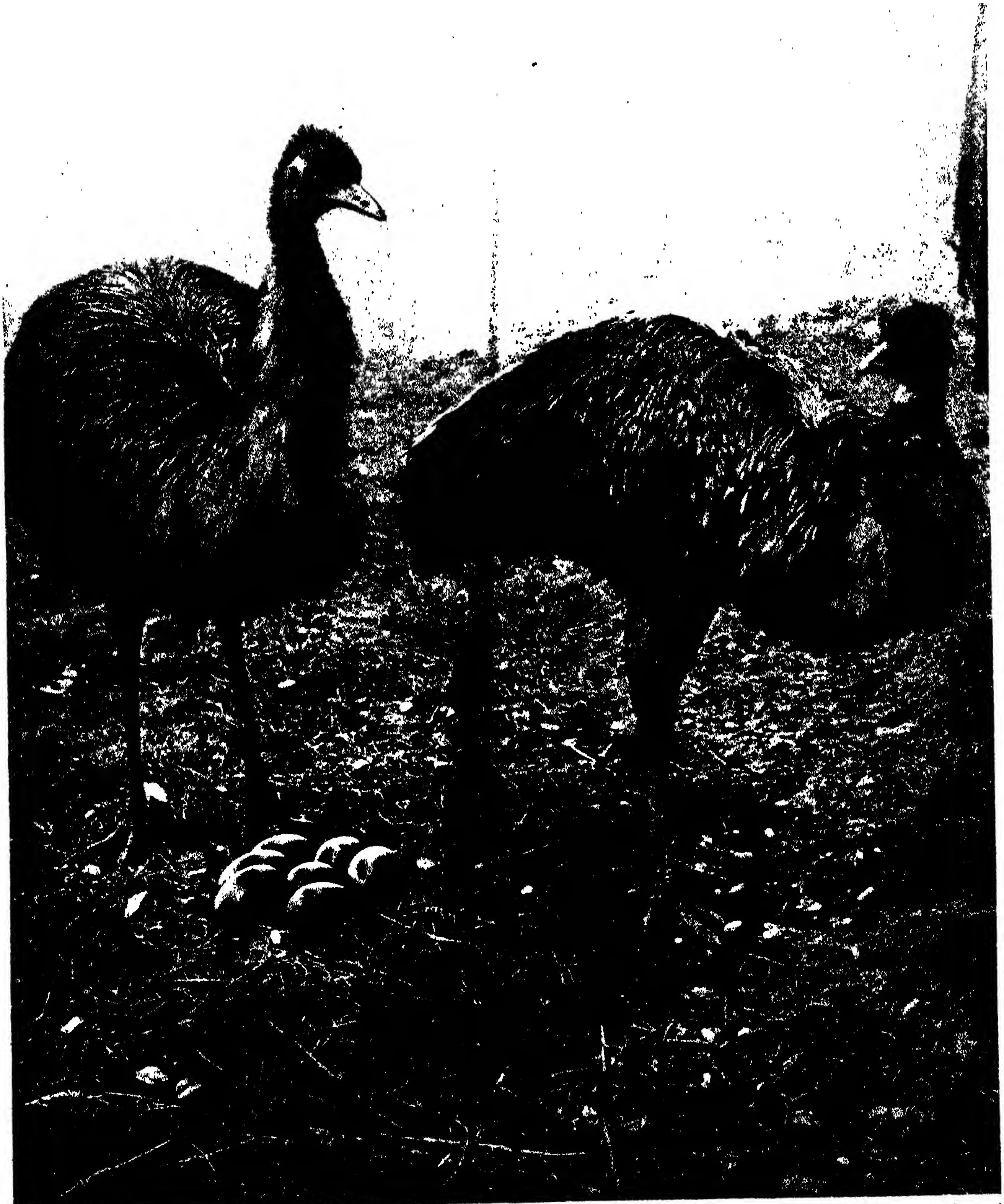
But the formation of the 500-acre open-air zoo at Whipsnade, in Bedfordshire, by the Zoological Society of London in 1931 was the greatest advance ever made. It soon bore fruits in the production by a tigress of a litter of

The mother hippopotamus had always shown a dislike for the garden-watering engine, so Mr. Bartlett arranged for this to be wheeled into the house in a direction that would, if the mother hippopotamus followed it, take her into her tank. The arrangement was that if she went into the tank a keeper should close the gates upon her while Mr. Bartlett slipped into the den and carried off the big baby.

However, success attended the effort, the baby was placed in a warm room on a bed of hay and covered with a blanket. Two goats supplied it with warm milk, which it took from a feeding-bottle, and for a time it lived. But unfortunately it did not survive for long.

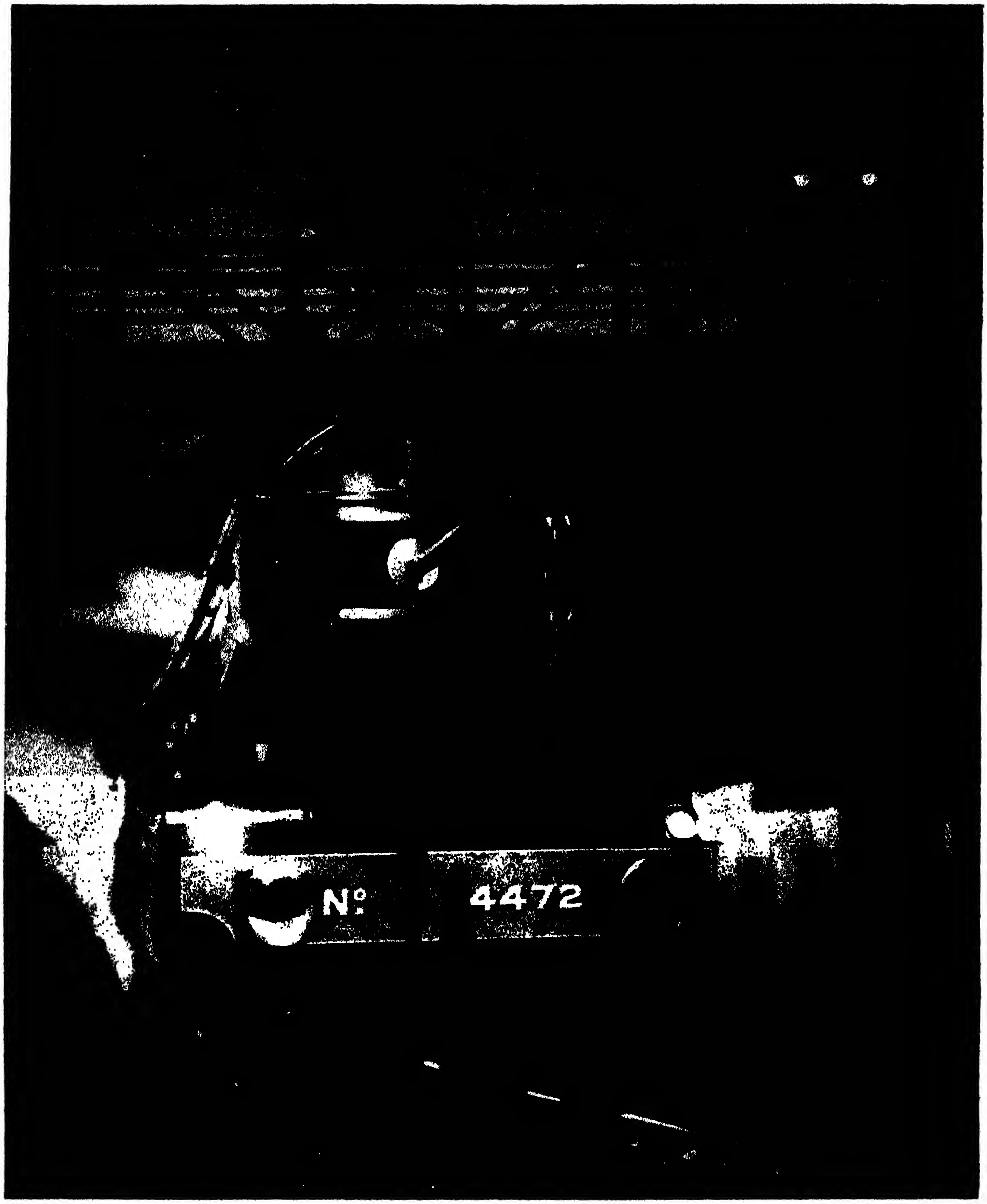
Much greater success attends the rearing of young animals now under the improved conditions and with the increased knowledge that has been gained in recent years from the studies of scientific men.

THE FLIGHTLESS EMU AND ITS EGGS



The emu of Australia is one of the four large flightless birds, the others being the ostrich of Africa, the cassowary of Australasia, and the rhea of South America. In size the emu comes next to the ostrich, and it is a formidable adversary when it kicks out with its muscular legs. It is easily tamed, but loves mischief, and will sometimes perform such tricks as chasing a man and removing his hat with its beak. The general colour is brown, mottled with grey and black. The two sexes are very similar, but the male is rather smaller than the female, and when the female lays her eggs it is the male that incubates them. These eggs vary in colour from dark green to a light bluish green, and there may be from nine to thirteen. They are about five inches long. Emus are good swimmers

A RIGHT WAY OF USING NATURAL FORCES



All around us we see ways in which man is using the forces and powers of nature for beneficent purposes. Were it not for the fact that men of science, working patiently, often at great risk to themselves, had wrested these powers from Nature we could not to-day travel comfortably at fifty or sixty miles an hour, as the passengers in this express train are doing. Nor should we have radio and the telephone and the cinema and a thousand other benefits. But we must always remember that such powers can be used for evil as well as for good. The wars of 1914–18 and 1939–45, with their lamentable destruction of life and property, were proof of that. There is no blessing that cannot be misused—motor-cars and printing and the cinema and broadcasting and so on—but if we all strive for goodness and a better world we shall be doing our part to insure that the powers of Nature as they are won shall be used only for good and true purposes.

HOW RADAR "SEES" INVISIBLE OBJECTS

As you can read in the article on page 1367, there is a layer of the atmosphere surrounding our earth which has the property of reflecting back to the ground the electromagnetic waves that carry radio signals. Now, meteorologists believe that the height and electrical density of the various layers of the atmosphere have an effect upon the weather; and that belief saved Great Britain from disaster in the first year of the 1939–45 War.

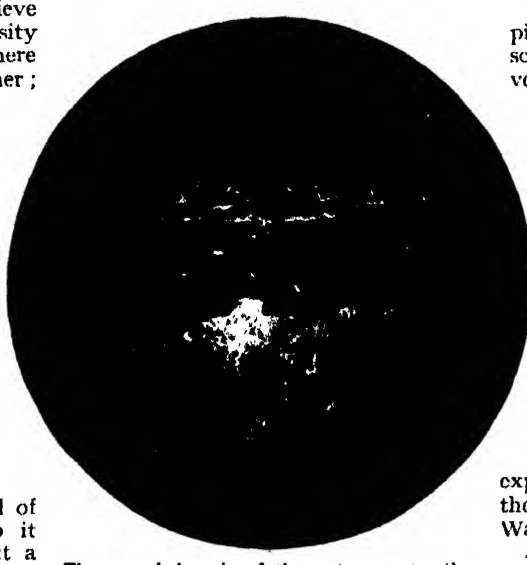
In 1924 two British scientists, Sir Edward Appleton and Doctor M. A. Barnett began trying to find out just how high were some of the atmosphere layers. They had decided that if they could transmit a certain type of radio signal straight upwards from the ground, and then pick up its echo or reflection back to earth, they would be able to measure its distance from the earth by calculating the time that signals took to make the double journey.

Radio waves travel at the speed of light, 186,000 miles a second, so it would be quite useless to transmit a radio signal and then time with a stop watch how long before the echoed pip was heard in a receiver. An error of one-hundredth part of a second would have made a difference in the calculation of over 000 miles.

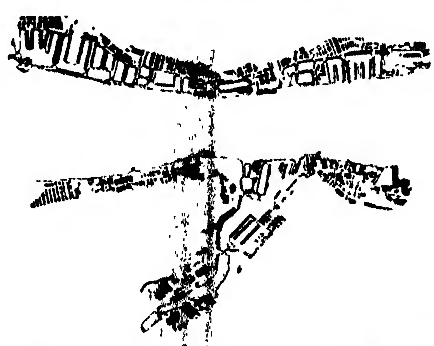
Accordingly, Appleton and Barnett designed a special type of cathode-ray tube, very like the screen of a television receiver. They then arranged for a spot of light to sweep backwards and forwards across the face of the cathode ray tube at a fixed speed and in a straight line. Thus, if the spot of light moved across the glass face in one-thousandth of a second, they had a thin line of light representing a distance of 186 miles.

Next the cathode-ray tube was connected to a radio receiver at Oxford and tuned in to a radio transmitter at Bournemouth. It was then discovered that every time the Bournemouth transmitter broadcast a pip, the spot of light on the cathode-ray tube at Oxford gave a slight flicker; but even more important, the kick or flicker on the tube was always followed an instant later by a second flicker. As only one pip was transmitted at a time, this proved beyond doubt that the second flicker was a reflection or echo of the first.

By measuring the distance between the flickers on the line of light across the cathode-ray screen, Appleton and Barnett worked out the height of the reflecting layer of atmosphere. The answer was about 70 miles. Eleven years later, in 1935, a team of scientists under Mr., later Sir, Robert Watson Watt, was experimenting at the Government Radio Research Station, Slough, Buckinghamshire, to find out what effect the reflecting layer of the atmosphere had on the weather. Their work was very similar to that undertaken by Sir Edward Appleton and Doctor Barnett, but their equipment had been greatly improved.



The map below is of the entrance to the River Mersey, and the lights on the screen (above) are the "blobs" reflected when the radar impulses strike the river banks



Here a radar operator is watching on a Cossor Plan Position Indicator a "picture" of the Mersey and instructing by radio-telephone the captain of a ship moving through the fog-bound river.

Then one day, while watching the pips appearing on the cathode-ray screen, Mr. Watt noticed something very strange indeed. A series of flickers suddenly began moving on the screen and represented echoes that had returned far too soon to have travelled back from any atmospheric layer above the earth. There was only one explanation the radio signals were being reflected back to the receiver from trees and houses some comparatively short distance away.

Further experiments proved that the radio signals were being echoed from a large building a few miles distant. Most people would have been content with finding out the cause of the unexpected echoes; and then to have let the matter rest. Fortunately, Watson Watt remembered something else.

At that time aircraft were able to travel at speeds up to 350 miles an hour, and for a country that might have to defend itself against air attack this was a serious threat. The only methods of detecting the approach of hostile aircraft was to see them or to pick up with sound locators the noise of their engines. High-flying aircraft are difficult to see even with the best of binoculars, while picking up the sound of aircraft was not always reliable, and unless the listener was well-trained he was apt to confuse the sounds of enemy and friendly aircraft.

The only sure way to detect hostile aircraft and shoot them down was to have fighter aircraft constantly patrolling the approaches to a target. This needed enormous numbers of fighters and was extremely wasteful of petrol and time.

On the other hand, if some means could be found to detect enemy aircraft while they were still a long way from their target, the defending fighters could stay on the ground until it was known from which direction the attack was coming. This would give the fighters sufficient time to take off and reach the place where they were most needed.

When Watson Watt found that radio signals could be reflected from buildings and other objects on the ground, he decided that there was no reason why they should not be reflected from moving objects such as aircraft. In co-operation with the Royal

Air Force, he made a number of experiments which proved him to be perfectly right.

Thus radar came into being, and it was the fact that it was in being at the outbreak of the 1939–45 War that the Battle of Britain was won by the Royal Air Force. Radio detection of aircraft was at first called radiolocation, and it was not until much later that the now better-known name " radar " came into use. Radar is an abbreviation of a Service phrase " radio detection and ranging " Various systems of radar were used throughout the 1939–45 War, but they all worked in the same way

Unlike radio used for sending messages or for broadcasting sound or television, the radar transmitter and receiver are located at the same place, and often use the same aerial. The receiver is tuned in for " listening " all the time, but the transmitter sends out its signals only a very small part of the time. These signals or, more correctly, energy pulses, are transmitted in very intense bursts of short duration, each pulse lasting only a millionth of a second.

After each pulse the transmitter automatically switches itself off for a few thousandths of a second before sending out the next pulse. During the interval between the pulses the receiver is working, and the signals it picks up on its cathode-ray tube are the echoes or reflections of the transmitted impulses from nearby or distant objects.

Near objects give echoes coming very soon after the transmitter pulse is finished ; those farther away give later echoes. The time between the transmission of the pulse and the reception of its echo gives the distance of the object reflecting the echo.

The elaborate electronic equipment that makes it possible to measure the time between the transmission of a pulse and the reception of its echo is one of the great achievements of radar. Since the speed of the impulse is 186,000 miles a second, or 328 yards every millionth of a second, and since the impulse must travel twice, there and back, an object 1,000 yards from the radar transmitter and receiver will give an echo in six millionths of a second.

Nevertheless, and despite these fantastically tiny fractions of time, the period between pulse and echo can be measured to within one-thirtieth of a millionth of a second. Put in another way, this is an accuracy to within five feet of every mile of distance.

Having worked out a method of measuring the time interval between a pulse and its echo, the scientist had to devise some means which would give the direction of the target. This is done by giving the radar set a directional aerial ; that is, one that sends out the pulses in a narrow beam, like that of a searchlight. The aerial is rotated as the pulses are transmitted, and the echoes are received when the aerial is pointing directly at the target. The echoes, or flickers on the face of the cathode-ray tube are strongest when the beam points directly at the target.

The navigational bearing or direction of the aerial is also the bearing or direction of the target, and is automatically registered on dials.

At the outbreak of the 1939–45 War, a chain of radar stations had been set up round the coast of Britain. The stations transmitted a wide and powerful beam of radar impulses out to sea and were able to record the presence of any aircraft in the sky while it was still many miles out of sight.

At first, radar could not distinguish between friendly and enemy aircraft, both of which echoed the impulses in the same way. Eventually this problem was overcome by the invention of a small radio transmitter fitted to allied aircraft. Immediately an aircraft fitted with one of the transmitters came within radar range, the impulses caused it to transmit a radio signal which identified the aircraft as a friend. The type of signal transmitted could be altered from hour to hour, so that there was no danger of the enemy using it to fly under false radio colours.

Radar was next developed to sight guns. A directional rotating aerial was electrically linked to the elevating and traversing mechanism of the gun. As the impulses were reflected back on to the cathode-ray screen of the receiver, every movement of the aerial was followed by the gun. A graph on the screen gave the height, distance and speed of the aircraft and at the right moment the gun opened fire with a reasonable chance of hitting a target the gunners could not even see.

Radar-controlled guns were used on battleships at sea and by field artillery firing against land targets. Another type of radar set was installed in aircraft so that enemy aeroplanes could be detected.

Unlike most military weapons, radar has conferred valuable benefits on the peace-time activities of the world. The drawing on page 340 and the article on page 1208 tell you how radar is used to " see " airliners approaching an aerodrome and how an airliner can land on a fog-bound airport.

By means of a Plan Position Indicator like that illustrated on the previous page, a port control officer can guide ships into fog-bound rivers and ports and direct them to a safe berth. With a Plan Position Indicator, the radar echoes are caused to draw a map of any particular place on the cathode-ray tube.

Although the radar operator is seated in a comfortable room ashore, it is as if he were suspended high above the fog area but able to look down through the fog to " see " the scene spread out below. No matter how many objects are there, each is indicated by a blob of light on the face of the tube. Blobs which do not move are the banks of the river, or buildings, wharves and ships at anchor, while the moving blobs are ships groping their way into the port.

The whole picture of the port and its activities is reflected back on to the screen by the echoes of the impulses.

Using the radar equipment shown on the previous page, the operator can pick up any ship moving in the Mersey and give to its master by radio-telephone information about every moving or stationary object in the 10-mile-long channel from the Bar Lightvessel to the dock area. If the moving blob on the radar screen indicates that the ship is in danger of running into anything, the operator can tell him how to alter course to avoid it.

At sea, ships use radar to find their way safely past all kinds of otherwise hidden dangers. Icebergs, floating wrecks, and other obstacles can be picked up by ship's radar long before they are close enough for the vessel to collide with them.

Colour Plates in this Work

GENERAL INDEX

The figures printed in italics indicate that there is an illustration, while the Roman figures refer to the text